FARMERS' COOPERATIVE FEED MILLS

PLANS AND OPERATIONS

By

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SUMMARY

Twenty-six farmers' cooperative feed grinding and mixing plants in eleven States were visited to study plant design and operations. While a few large feed manufacturing plants were included, the study was confined largely to those serving farmers in a community or area with similar feeding practices.

The number of different feeds manufactured range from 7 to 26 at the several plants.

The mills studied included both batch and line mix types. The small batch mix plants ranged in capacity from 1 to 2 tons per hour; batch manufacturing plants from 10 to 18; and line mix plants from approximately 20 to 30 tons per hour.

The small batch mix mills employed 2 to 4 men, the batch mix manufacturing plants 17 to 32, and the line mix plants from 20 to 40 men.

Small batch mix mills are operated by co-op elevators or warehouses. A building designed for the purpose without grain storage facilities but with a warehouse about 30 x 120 feet and new machinery capable of turning out 1 to 2 tons of feed per hour cost from $25,000 to $35,000 to construct in 1947.

Batch mix manufacturing plants constructed during recent years with a capacity of 10 to 15 tons of feed per hour and storage for 50,000 to 60,000 bushels of grain represent an investment of $300,000 to $400,000 Line mix plants with a rated capacity of 25 to 30 tons per hour and with comparable grain storage are reported to cost $500,000 to $600,000 or more.

None of these mills made a practice of delivering feed in bulk but several were experimenting with equipment for this purpose.

Some mills use only new bags and others make full use of bags returned by patrons. The practice of reconditioning bags varies. Practices and opinions differ also as to the use of screenings.

The design of a feed mill depends upon whether custom grinding is to be done, the kind of feed to be manufactured, and maximum desired capacity. Unless the different operations are synchronized and equipment provided for the capacity desired, an inefficient plant will result. Several of the mills visited had bins, an elevator, a mixer, or some other piece of equipment which constituted a bottleneck in operations.

Feed mills follow the general pattern of grain elevators and seed cleaning plants in that the materials are elevated high enough for processing while they move by gravity back to first floor level. Heavy expensive construction is therefore required as machinery must be installed on practically all floors. For these reasons, some designers are working on plans whereby the bulk of the machinery may be located on one floor.

Feed mills of conventional design require experienced builders with special equipment not generally available in some areas except for big jobs. Small mills therefore need to be designed that can be constructed by local builders in most any part of the country.

Hand trucks were used exclusively at small mills for handling bags of feed and ingredients. Large mills used belt conveyors and pallets, or a combination of both. The quantity of feed manufactured, materials handled other than feed, and the layout of the mill influence the successful use of pallets.

Hopper bottoms in bins for grain usually slope about 45 degrees and those for ground materials 60 to 70 degrees. Bins for ground grain and mill feeds are often hoppered to one corner for reducing the tendency of the material to arch or bridge over.

If snapped corn is to be received, equipment designed for the purpose should be secured and only the shelled corn handled by the regular feed mill machinery.

Elevators with buckets for handling a variety of materials are available and should be selected according to the capacity desired.

Screw conveyors are widely used despite possible mixing of different materials. Their cost is relatively low and they require little space compared with a belt conveyor. Experiments in handling feed ingredients with small air pipes in a positive pressure air pump system might be worth while.

Hammer mills are reported as the most versatile of the grinders used for feed and were used in all plants studied.

The majority of the small batch mix mills studied used vertical mixers while the manufacturing plants used the horizontal type mixers.

Pellet mills are relatively new and the machinery for them has not been developed to a point comparable with some other feed milling machinery.

Attachments for platform scales, regular bagging scales, and bag closers are time and labor saving devices that should be more widely used in small mills.

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By

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in cooperation with

Farm Credit Administration

High production of meat and eggs per unit of feed consumed is the order of the day, especially in view of the high cost of feed. The commercial production of broilers and turkeys has demonstrated the importance of palatable and highly nutritive feed in getting young birds off to a good start. Good feed is, of course, also important for dairy cattle. The proportion of feed actually utilized by a dairy cow for milk production may vary from 30 to 60 percent, depending upon the cow and the feed.[1]

Climate, soil fertility, kind of crop, method of harvesting, and storage, all influence the nutritive value of home grown feed. Corn, for example, is one of the best feed grains but may need to be combined with other feeds in a ration because of deficiencies in proteins, minerals, and vitamins. In grain deficiency areas a complete feed may be necessary depending upon the livestock and available pasture.

The grinding of grain or roughage does not increase nutritive value of feed but may improve its palatability. Grinding also makes possible the mixing of ingredients in proper proportions. For example, it would be difficult, if not impossible, to add trace elements or vitamin carriers to a feed unless the grain and forage were ground.

Some manufactured feeds carry 15 or more ingredients. The job of bringing them together in proper proportions, mixing, and getting the feed in bags requires facilities beyond the reach of most farmers. As a result, many farmers' cooperatives have been organized for preparing livestock feeds.

The sizes and types of feed mills vary widely over the country depending in part on the feeding practices in the area and whether the mill is located in a grain surplus or deficit region. Moreover, the design and construction of feed mills, especially large ones, is a specialized business. A number of questions of a general engineering nature must

[1] Woodward, T. E. Feeding Dairy Cows. U. S. Dept. Agr., Farmers' Bul. No. 1626. 33 pp. 1930. Revised 1940.

NOTE: The study on which the report is based was conducted under the general supervision of J. G. Knapp, in charge, Purchasing Section, Cooperative Research and Service Division, Farm Credit Administration. The drawings were prepared by G. A. Amacker, Agricultural Engineer, B.P.I.S.S.A.E. Credit is due Lacey F. Rickey, Agricultural Economist, Cooperative Research and Service Division, for assistance in making the study and feed mill managers for plans and information on operations.

be answered, in the initial planning stage of any mill, to obtain an efficient plant. In order to assist farmers' cooperatives and others in planning feed mills, a study was made in 1947 by the Cooperative Research and Service Division of the Farm Credit Administration, in cooperation with the Bureau of Plant Industry, Soils and Agricultural Engineering, of typical installations in 26 mills in 11 States. While a few large mills were visited, the report deals mostly with those serving farmers in a community or area where feeding practices are similar.

This report is designed to give boards of directors of farmers' cooperatives and others interested a general idea of what is involved in the construction and operation of feed mills of various sizes. Each mill must be designed to meet a variety of local conditions. Services of an engineer experienced in mill design and operations are desirable in all cases and indispensible for the larger mills. While the Farm Credit Administration can confer with cooperatives relative to their general requirements and the economic factors involved, it is not prepared to draw up plans or render engineering service.

TWO TYPES OF MILLS

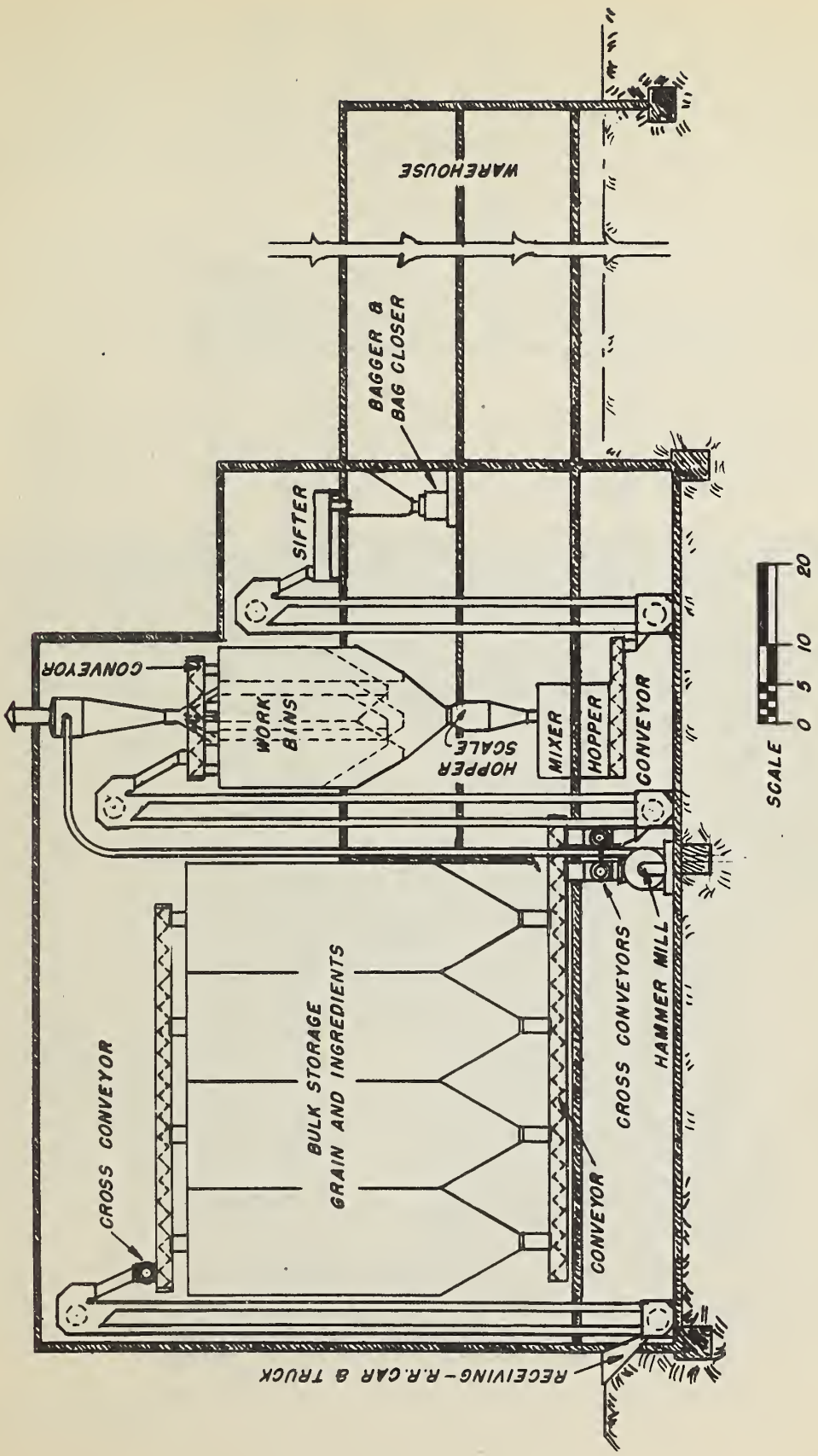
There are two types of feed mills - batch and line mix plants. Small mills with a capacity of 1 to 2 tons of feed per hour are of the batch type as well as many manufacturing plants with a capacity of 10 to 15 tons per hour. Plants designed for a capacity of more than 15 tons per hour are usually of the line mix type. However, some of the new batch mix manufacturing plants visited have facilities for a capacity greater than 15 tons per hours.

In the one type, as the name implies, feed is mixed in batches, and in the other, mixing is a continuous process. The two types are illustrated in figures 1 and 2. Such plants usually manufacture pellets and scratch feeds but the mash line only in shown.

Both types of mills have their advantages and disadvantages. Machinery for line mix plants is reported to be more expensive but line mix plants require less labor per ton of feed than the batch types. Mill operators report it is easier to accurately mix the necessary ingredients in a batch mix than in the line mix plant. Mechanical feeders in a line mix plant must be checked frequently for the desired rate of discharge, especially if feeds from several formulas are manufactured each day.

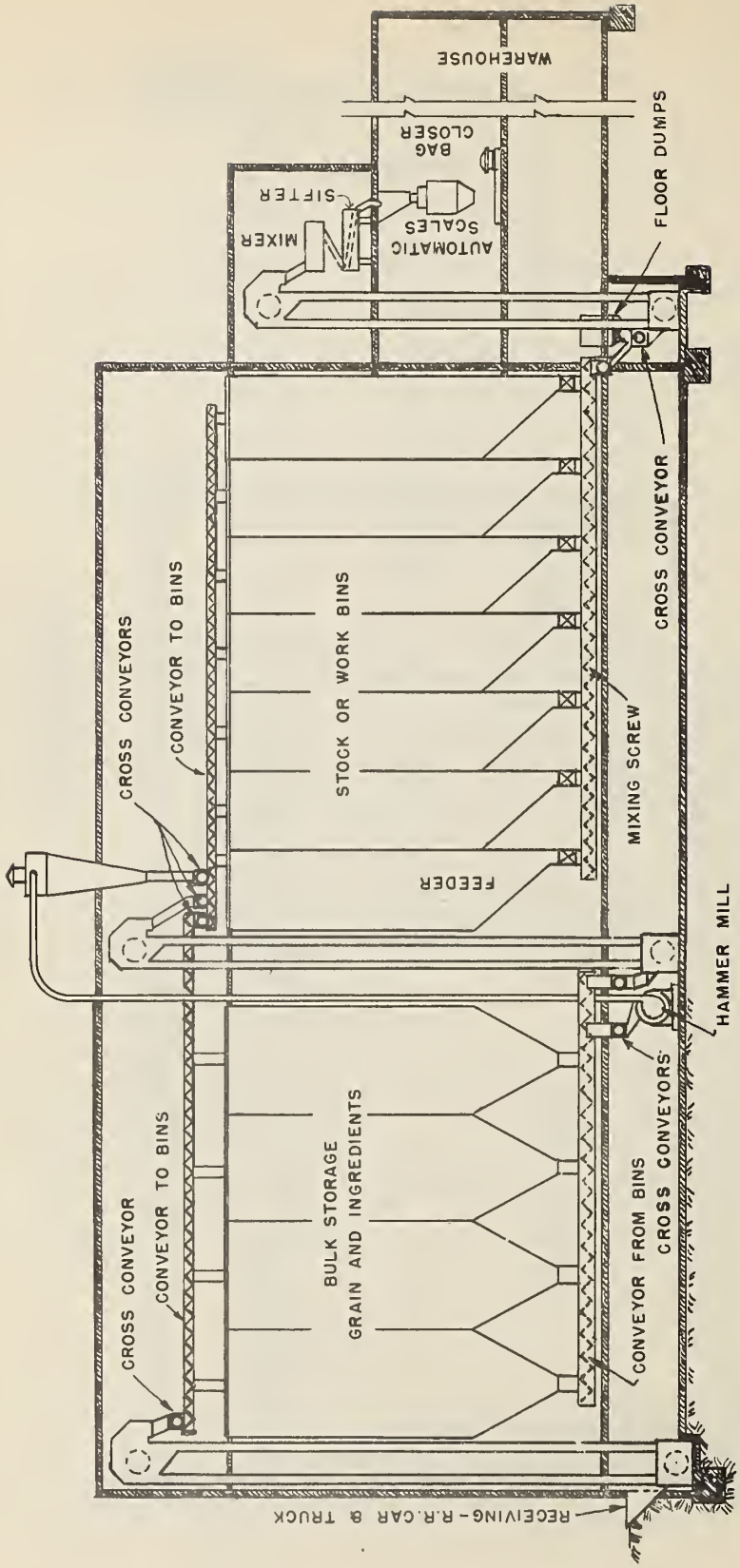
BATCH MIX PLANTS

The feed manufacturing plant illustrated in figure 1 is shown with bulk storage for both grain and ingredients. Some ingredients which are difficult to handle in bulk, and those which constitute a small part of a particular feed, are handled in bags. At small mills all ingredients, except ground grains, may be handled in bags.



BATCH MIX FEED MANUFACTURING PLANT-DIAGRAMMATIC

FIGURE I



LINE MIX FEED MANUFACTURING PLANT - DIAGRAMMATIC

FIGURE 2

The work bins, usually about 15 in number, conveniently bring together the several ingredients for weighing and mixing. The hopper, mounted on scales for rapid weighing, receives the ingredients from the work bins prior to mixing. The hopper over the sacking scale provides temporary storage from which to sack while another batch is mixed. A batch plant, with equipment balanced as to capacity, can turn out feed in a continuous stream.

In a batch mix plant grains are conveyed from storage to a hammer or attrition mill and ground for the work bins as needed. Ingredients from bulk storage also are supplied to the work bins as needed. The operator manipulates valves in the hopper bottom work bins allowing ingredients, one at a time, to flow by gravity into the scale hopper (figure 3).

The unit shown consisting of the hopper for the scales, valve box, and the lever assembly is a manufactured product. For many years it has been customary to construct these units locally. Another innovation in batch mix manufacturing plants is a screw conveyor from each work bin to

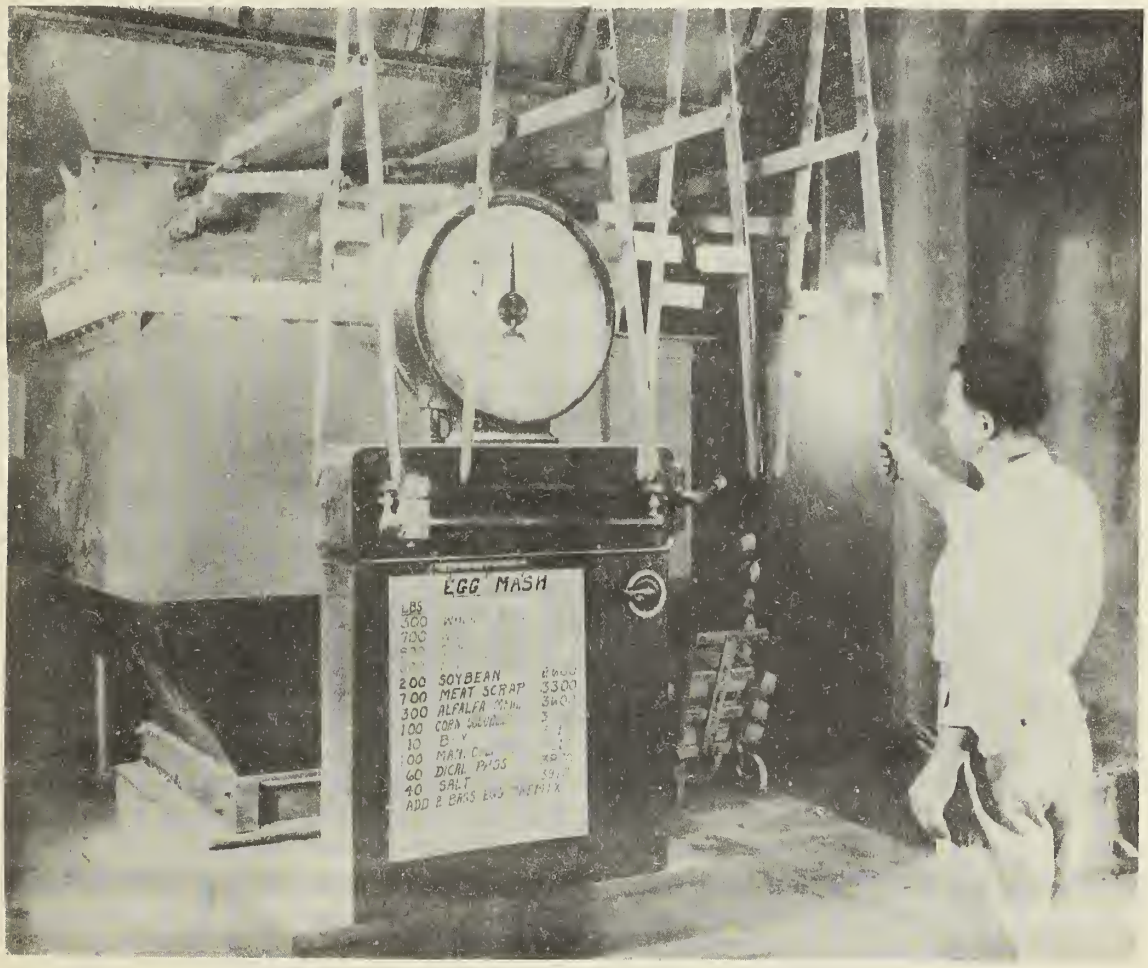


Figure 3. - Weighing ingredients in a scale hopper prior to mixing at a batch mix feed manufacturing plant.

the scale hopper. The operator holds in a motor switch until the screw has delivered the required quantity of the ingredient.

Ingredients needed in small quantities or those which are difficult to handle in bulk are dumped from bags into the hopper scale or directly into the mixer. Sugh ingredients are sometimes combined in a premix for convenience in handling. When the several ingredients for a batch of feed, as prescribed by a feed formula, have been weighed the contents of the scale hopper is dumped into the mixer.

The size of the batch depends, of course, on the capacity of the mixer. Mixers of 1, 1-1/2, and 2 ton capacity are common. Some mills have two mixers which may be charged alternately by gravity or conveyor from the same scale hopper. Feed from the mixer moves direct or from a surge bin, either by gravity or conveyor, to an elevator. The elevator deposits the feed on a sifter over the bin from which it is bagged. In large plants, automatic scales are used for weighing and bagging and a power driven sewing machine closes the bags. From the sewing machine the bags of feed move by belt conveyor, pallets, or on hand trucks to the warehouse or direct to trucks or railroad cars.

LINE MIX PLANTS

The storage of grain and ingredients in a line mix plant and the grinding of grains differ little, if any, from such operations in a batch mix plant. However, the stock or work bins are usually larger and the ingredients are fed from them by mechanical feeders into a mixing screw. (See figure 2.) This screw also conveys the feed to an elevator which deposits it on a sifter. From the sifter the feed moves by gravity into a continuous high speed mixer and then either to the automatic scale for bagging or, is diverted, to the pellet line. After the bags are closed, the finished feed is moved by hand truck, pallets, or conveyor to the warehouse for storage or shipping.

The floor dumps to feeders, as illustrated, are provided for small lot ingredients and for rerunning a few bags of feed accumulated when starting and stopping the line. A small quantity of feed at the beginning and end of a run does not contain all the ingredients and, therefore, must be fed back into the line when it is in full operation, for remixing.

FEEDS MANUFACTURED

The number of formula mash feeds manufactured by the plants studied ranged from 7 to 26. The great number and variety of feeds seems to increase from year to year and is of concern to manufacturers. A large number of formulas and frequent changes in formulas are not conducive to high mill capacity and low cost feeds.

The actual number of feeds turned out depends upon the size of the mill, its geographic location, and the kinds of livestock produced in the area served. A large mill may serve an area comprising a variety of livestock

enterprises. On the other hand, poultry and dairy cooperatives sometimes have their own feed manufacturing plants.

In addition to formula feeds, the large mills produce scratch and pellets. Scratch is a mixture of whole or cracked grains and may be mixed according to several formulas. Pellets are formed from mash and a mill may furnish pellets made from most any feed formula. Pellets are gaining in popularity especially for range feeding and for turkeys. For this reason new manufacturing plants are arranged so that any mash, including molasses mix, may be routed to the pellet mill during the manufacturing process.

Small batch mix plants, which do mostly custom grinding, may prepare only a few mash feeds. At these mills, farmers bring in their grain to be ground and for the addition of supplements. Some, of course, prefer to deliver their grain and obtain feed rather than to wait for their own grain to be ground. These mills also may supply scratch feeds, mostly cracked corn, but seldom have pellet mills because of the expense involved.

The grains used in manufactured feeds are principally corn, oats, wheat, barley, and grain sorghums. The kind and quantities of each used depend largely upon the price, availability, and kind of feed manufactured. Corn is, of course, the principal feed grain used, with oats next, but wheat and barley are used widely on the west coast. In the Southwest grain sorghum is an important grain for mixed feeds. Meal from artificially dried alfalfa is used extensively in mixed feeds because it is a source of vitamin A and has a high protein content.

MILL CAPACITY

The capacity of the mills visited as reported by the management is shown in table 1. These figures represent spot checks on performance but should give a general idea of the capacity of mills studied. The small batch mix plants ranged in capacity from 1 to 2 tons per hour; batch manufacturing plants from 10 to 18; and line mix plants from approximately 20 to 30 tons per hour.

With one or two exceptions, all of the small batch mills visited were operated in conjunction with grain elevators or had storage nearby for gravity flow of grain as needed for the hammer mill. The capacity as shown for these feed mills is based on full time work for the crew with no time out for receiving ingredients from railroad cars or for loading farmers' trucks with feed. Mills are often operated seasonal and on a part time basis. However, they can and do turn out feed at the rate shown when devoting full time to this job.

The capacity shown for the batch and line mix manufacturing plants is based on performance over a period of a month or more in several cases. In other instances, the capacity is indicative of maximum output of feed actually manufactured under favorable conditions. However, several of the plants could increase the capacity shown, resulting in an increase in labor efficienty.

Table 1. - *Mill capacity and workers employed at batch and line mix mills*

Plant number	Date opened	Capacity tons per hour	Number of employees[1]	Man hours per ton
Small batch mix mills				
2	1933	1.9	4	2.1
3	1942	1.0	2	2.0
4	1947	1.2	2	1.7
6	1947	1.5	3	2.0
7	1947	1.2	3	2.5
Batch mix manufacturing plants				
5	1946	12.0	17	1.4
12	1937	10.9	13[2]	1.2
13	1938	15.0	15[2]	1.0
15	1946	18.0	32[2]	1.8
Line mix manufacturing plants				
8	1947	28.0[3]	20	.7
9	1947	30.0	40	1.3
10	1938	27.0	27	1.0
11	1938	20.0[4]	33	1.7

[1]Mill superintendent, foremen, and workers for receiving, milling, warehousing, and loading feed on trucks and cars.

[2]Excludes three persons sorting, cleaning, and disinfecting bags.

[3]Estimate.

[4]Obsolete equipment.

Millers do not like to operate with more than two or three days supply of feed ahead. Warehouse space for finished feeds, at the mills visited, seldom exceeded mill capacity for more than five days. Fresh feed is one of the advantages claimed for mills serving local areas. Also, frequent changes during the day in the kind of feed manufactured cut down on capacity, particularly in the case of line mix mills. However, some of the old well established mills and those with orders at or above mill capacity are able to run full time day after day, operating one or more shifts. Some mills operate 24 hours a day for long periods when demand is heavy. The capacity shown for manufacturing plants includes mash, pellets, and scratch. In one or two cases some whole grain, sacked from bulk storage for use as feed, is included. For the small mills the tonnage shown is mostly mash.

The output of a small mill depends, of course, on how well different operations are synchronized, capacity of the several pieces of equipment, and the convenient arrangement of supplies and equipment to save steps and handling. Observations and time studies show that two men with floor scales for weighing the ingredients, bins for ground gain, a ton mixer, and a hand or power operated sewing machine for closing bags have no difficulty in turning out a ton of feed per hour. This includes time required to bring bags of ingredients from an adjoining warehouse and for storing the feed in the warehouse in piles five or six bags high. The grain, of course, can be ground while the feed mixing operations are in progress.

The capacity of feed manufacturing plants depends upon many factors but there is a limit to the rate at which a crew can bag the feed. Modern automatic bagging devices can be operated by one or two men. Two experienced men can bag and sew, without difficulty, at the rate of 24 tons per hour and one man at from 14 to 15 tons per hour. Some mills report 30 tons per hour for two men.

None of the batch mix plants visited had facilities for mixing feed fast enough to keep two men busy full time on the automatic bagger. While a line mix plant may be geared for 30 tons per hour, time out for changing formulas and in adjusting feeders will naturally reduce this rate. However, a line mix plant with the usual layout of bins and feeders for one line and modern automatic baggers is usually rated at 30 tons per hour including pellets. For greater capacity more lines or production units must be added.

The capacity of pellet mills depends upon the diameter of the pellets produced, feed formulas, the size of the mill, and the arrangement of equipment. One plant with two 30 horsepower pellet mills reported a capacity of 2-1/2 tons of pellets per hour, and another 3 tons per hour. Capacity of the scratch line depends upon the number, size, and arrangement of bins and the capacity of the machinery. Mills manufacturing principally poultry feed may have a scratch line comparable in capacity with that of mash.

LABOR REQUIREMENTS

Two to four men are ordinarily employed in small batch mix plants. In some cases the crew also operates a grain elevator. Furthermore, a fuel and farm supply business is often carried on in conjunction with the elevator and feed business. Therefore, the number of employees shown for the small mills is not entirely comparable with those shown for manufacturing plants as no supervision, nor the time consumed in receiving grain and ingredients, is included. Adjustments for supervision and labor, not accounted for in feed manufacturing, would probably raise the labor requirements to at least two or more man hours per ton for all of the small batch mix plants included in the survey.

The crew, including the superintendent and foremen, for the batch mix manufacturing plants, ranged from 17 to 32; for the line mix 20 to 40.

At several plants, feed manufacturing is not the only business. In these cases the number of employees include only those used on feed in connection with the mill capacity shown. Since only a few of the mills cleaned and disinfected bags these employees, usually three in number, are omitted.

Judging from the spot checks shown in table 1, small batch mix plants might be expected to operate with from 2 to 3 man hours per ton; batch manufacturing from 1 to 2, and line mix plants at perhaps 1 to 1-3/4 man hours per ton. Unfortunately, two of the line mix plants visited had operated for only a short time and a third expected to move to a new location and had not replaced obsolete equipment. One old well-established line mix plant was observed operating with an expenditure of approximately one man hour per ton.

INVESTMENT

The small mills studied were located in structures of various types and in grain elevators. In one or two places a mill building had been designed and constructed recently for the business. Judging from those cases and general observations, a batch mix plant without grain storage facilities but with a warehouse perhaps 30 x 120 feet for finished feeds and sacked ingredients, and with new machinery capable of turning out 1 to 2 tons of feed per hour, would cost $25,000 to $35,000 to construct and equip in 1947.

Batch manufacturing plants constructed recently, with a capacity of 10 to 15 tons of feed per hour and storage for 50,000 to 60,000 bushels of grain, represent an investment of $300,000 to $400,000. A line mix plant, capable of turning out 25 to 30 tons of feed per hour with comparable grain storage capacity, is reported to cost $500,000 to $600,000 or more.

BULK DELIVERIES

There is general interest over the country in bulk deliveries of mixed feeds to the farm. Such a practice might result in a reduction in the cost of feed because the cost of bags, as well as labor for bagging, could be eliminated. However, separation of the light and heavy particles in the mix due to vibration over the road is one obstacle. Much could be cone in remixing while unloading at the farm but farmers generally do not have suitable bins for receiving the feed from a bulk delivery truck. Also, trucks capable of transporting a large tonnage are necessary for low cost transportation and these vehicles often have difficulty in getting to a farmer's bin. The large number of different feeds and the small quantities of each which must be carried on a delivery route are handicaps. Experienced millers doubt that 100 percent bulk deliveries will be possible. However, with suitable truck bodies and farm bins to receive the feed, mills in some parts of the country might use bulk delivery to advantage on many farms.

Several of the plants visited are experimenting with truck hoppers, conveyors, and low cost farm feed bins for bulk deliveries but none of them make a practice of delivering mixed feed in bulk.

USED BAGS

Opinions differ widely as to the use of second-hand bags for feed. Some mills use only new bags and others make full use of bags returned by patrons. Others restrict the use of used bags to feed for certain classes of livestock. The practice as to reconditioning bags also varies. Some mills sort them and discard the dirty and torn ones. A few have facilities for cleaning, mending, and disinfecting second-hand bags.

The bag cleaners observed were of the regular commercial air suction type which turns the bags inside out and whips them vigorously by means of an air current. The operator opens the top of the bag and holds the open end under the open end of a pipe on the suction side of a fan which discharges into a dust collector. The bag is immediately turned inside out as it is drawn into the pipe. The bag is then removed and the process repeated. This turns the bag back to the original position.

There seems to be a lack of information regarding the bacteria or insects which may be found in, or on, used burlap or cotton feed bags. However, it is generally assumed that any used feed bag may be infected with disease producing organisms present on the premises where the contents of the bag was fed. Because of this possibility of spreading livestock and poultry diseases by the use of second-hand bags, and the high cost of new bags, mills are generally interested in methods and equipment for disinfecting bags.

Various chemicals and gases have been tried. Formaldehyde gas is sometimes used but it has certain disadvantages and limitations. It is reported as ineffective at temperatures much below 65°F., its action superficial, and a long period of exposure in a sealed room is necessary.[2]

Persons familiar with disinfecting fabrics are generally of the opinion that steam under pressure, as in an autoclave, is the most effective of all known methods. An exposure of 15 minutes under steam pressure of 15 pounds per square inch is considered sufficient. It is assumed, of course, that devices such as a vacuum pump and vents are provided for obtaining heat penetration and uniform temperatures throughout the mass of bags in the chamber.

SCREENINGS

Some mills use only grains of commercial grade in their feeds and no screenings. Others use their own screenings as well as those from other sources. The advisability of using screenings can be determined only on the basis of local conditions.

[2]Tilley, F. W. The Use of Disinfectants on the Farm. U. S. Dept. Agr. Farmers Bul. No. 1991. 17 pp., illus. 1947.

Noxious weeds are prevalent in many sections of the country, parts of which may get into feed from screenings. It is also possible to spread weed seed in such materials unless finely ground. Nematod infection of certain grass seed screenings is known to be toxic. Foreign material in the screenings also may cause excessive wear on machinery. Nevertheless, the use of screenings may be justifiable in some areas.

PLANT DESIGN

The design of feed mills follows the general pattern of grain elevators and seed cleaning plants. Forty percent or more of most mixed feeds is grain. Therefore, feed mills work well in conjunction with conventional grain handling and storage establishments. However, interested persons should determine whether custom grinding is to be done, the kind of feed to be manufactured, and the maximum desired capacity of the mill before any attempt is made to locate or design a building for a mill. Otherwise, an inefficient plant will be the result. Several of the mills visited had bins, an elevator, a mixer, or some other piece of equipment which constituted a bottleneck in operations.

Another first step in planning a mill is to check with local or State officials on building codes applicable to the industry. Provisions for fire prevention and control and the prevention of dust explosions are most important.

In designing a plant an attempt should be made to provide for and arrange bins, elevators, and other pieces of equipment so that all major operations can be performed simultaneously and with a minimum of labor. The bulk handling of ingredients usually saves labor and should be provided for whenever practicable. Bins to receive carlot shipments of ingredients should be sufficient in size or number to hold at least one and a half, if not two cars. Otherwise, delays will occur in mill operations while awaiting deliveries.

Farmers' cooperatives which operate both large and small mills do not always agree as to the relative advantages and disadvantages of manufacturing plants as compared with small country point mills. The large ones have the advantage as to labor efficiency and should be able to mix feed with a greater degree of accuracy.

On the other hand, the small mills are close to the consumer and can give attention to the feed requirements and needs of individual farmers. They also may be operated in conjunction with some other business and spread the work for employees. In addition, there is the question of freight rates for ingredients and feed to be considered for both large and small mills.

It is usually advisable to plan a complete mill from the ground up rather than to place feed making equipment in an existing warehouse or other building. The usual experience has been that while the cost of an old building may be rather low, that of the complete mill with necessary alterations and equipment approaches the cost of an entirely

new plant. In such a converted plant it is difficult to arrange an efficient flow of materials through the various steps with the result that operating costs are high.

Sketches of the several types of mills, which appear later, are based on existing plants with changes and omissions for illustrative purposes only. For example, all the feed manufacturing plants sketched had dust-collecting systems of one kind or another, fire control facilities, and communication systems. In several of the drawings illustrating small mills, changes in equipment and layout have been made for possible improvements in performance. Figures 8 to 14 are examples.

In addition to the illustrations shown in this report some manufacturers of feed mill equipment and trade publications provide plans helpful in planning a mill.

SMALL BATCH MIX PLANTS

These mills may be located in grain elevators, warehouses, barns, and in structures designed for the purpose. Those not located in elevators are usually close enough to receive grain from an elevator either by gravity flow or conveyor. A mill for custom grinding designed as an integral part of a grain elevator is illustrated in figures 4, 5, 6, and 7.

This mill is located in an area where farmers bring in their grain to be ground and mixed with supplements. Corn also is brought to the elevator to be shelled. With this type of layout, the grain is weighed before grinding and ingredients are fed to the mixer from the floor. Feed is loaded in bulk by a feed elevator when the farmer so desires. Ground grain also may be spouted to the farmer's truck from the hammer mill cyclone. The cyclone or dust collector is a device for separating the ground grain from the blast of air which elevates it from the hammer mill to the top of the plant.

Feed mills are often added to an existing elevator on one side adjacent to the railroad track or across the drive on the opposite side from the track. Operators familiar with these different arrangements usually prefer the mill on the side of the elevator next to the railroad. Otherwise, ingredients received or feed shipped by rail must be trucked across the pits and through the elevator building.

In operating a small mill, grain is ground as needed and ingredients such as soybean and alfalfa meal in bags are trucked in from the warehouse for a batch of feed. The ingredients are weighed and dumped into the mixer in the order and in the quantities prescribed in the feed formula. Materials in bags of known weight are dumped without weighing. The feed is then mixed, and bagged, the bags closed, and the feed stored in the warehouse.

A small mill constructed near an elevator with floor bins for ground grains arranged for gravity flow into a wheelbarrow is illustrated in figures 8 and 9. All machinery is located on one floor and arranged for

FIGURE 4
MILL No. I- GRAIN ELEVATOR & FEED MILL COMBINED
-CUSTOM GRINDING - SECTION A-A

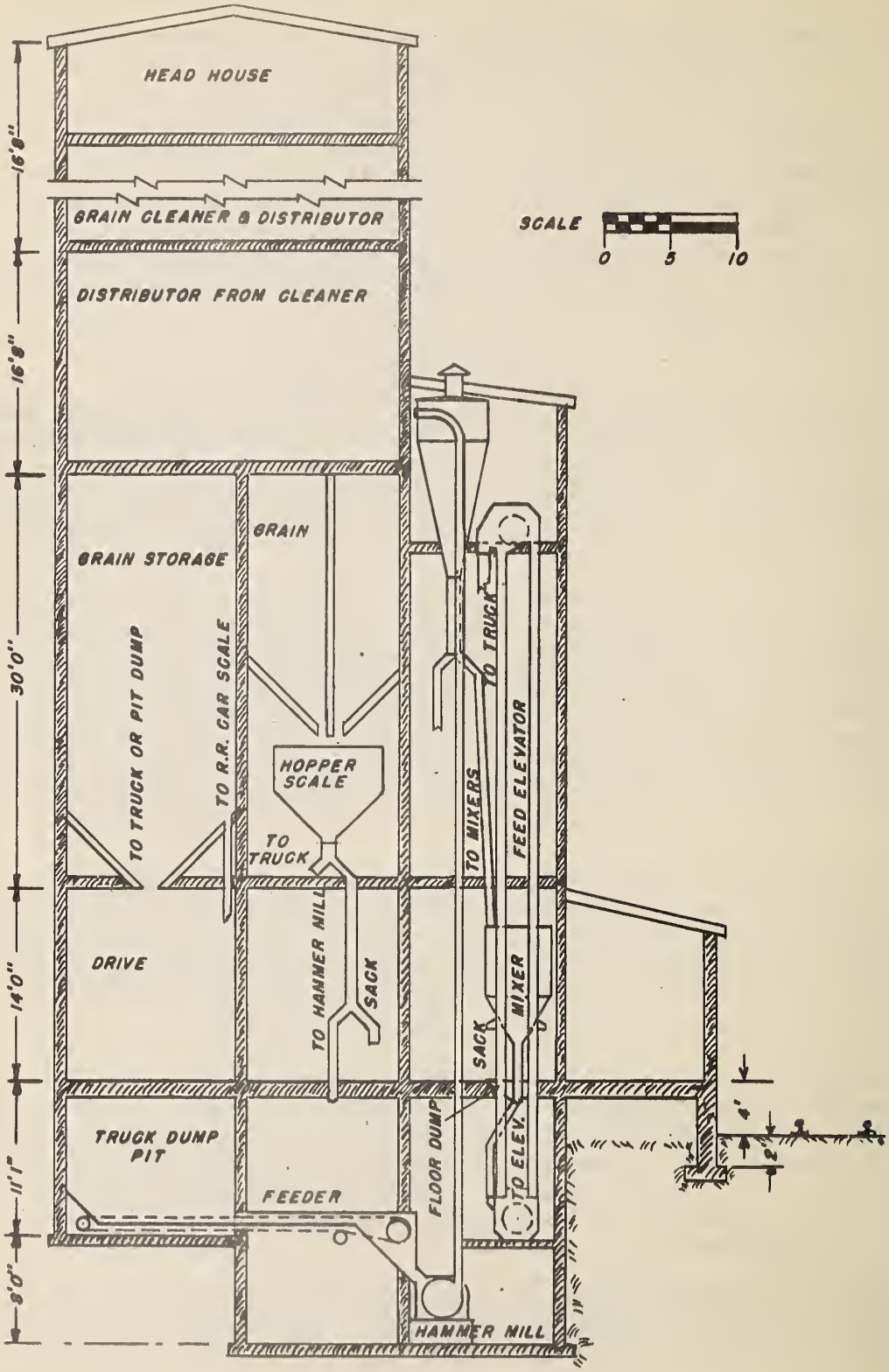


FIGURE 5

MILL No. 1-GRAIN ELEVATOR & FEED MILL COMBINED
— CUSTOM GRINDING —

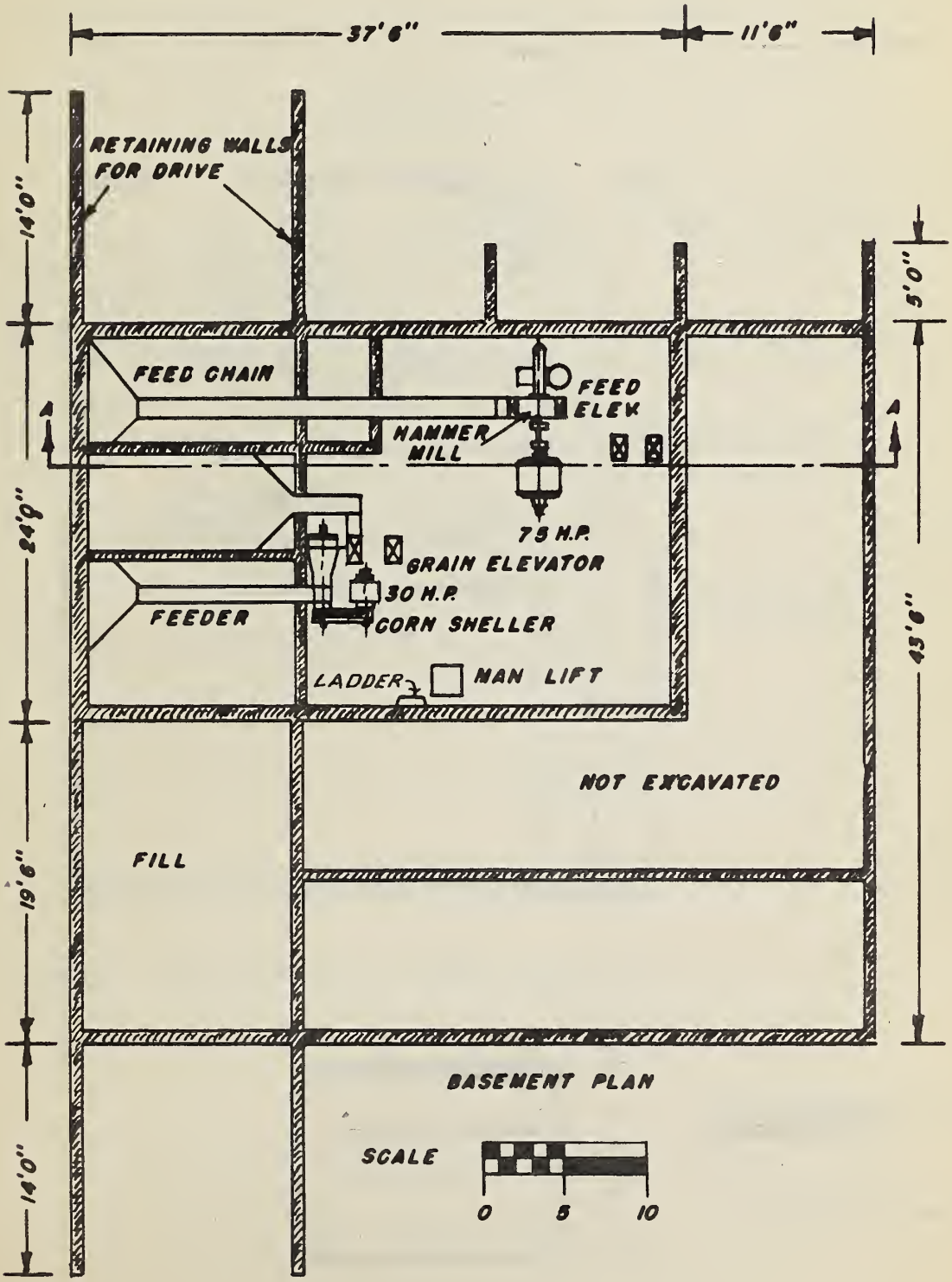


FIGURE 6

MILL No. 1-GRAIN ELEVATOR & FEED MILL COMBINED

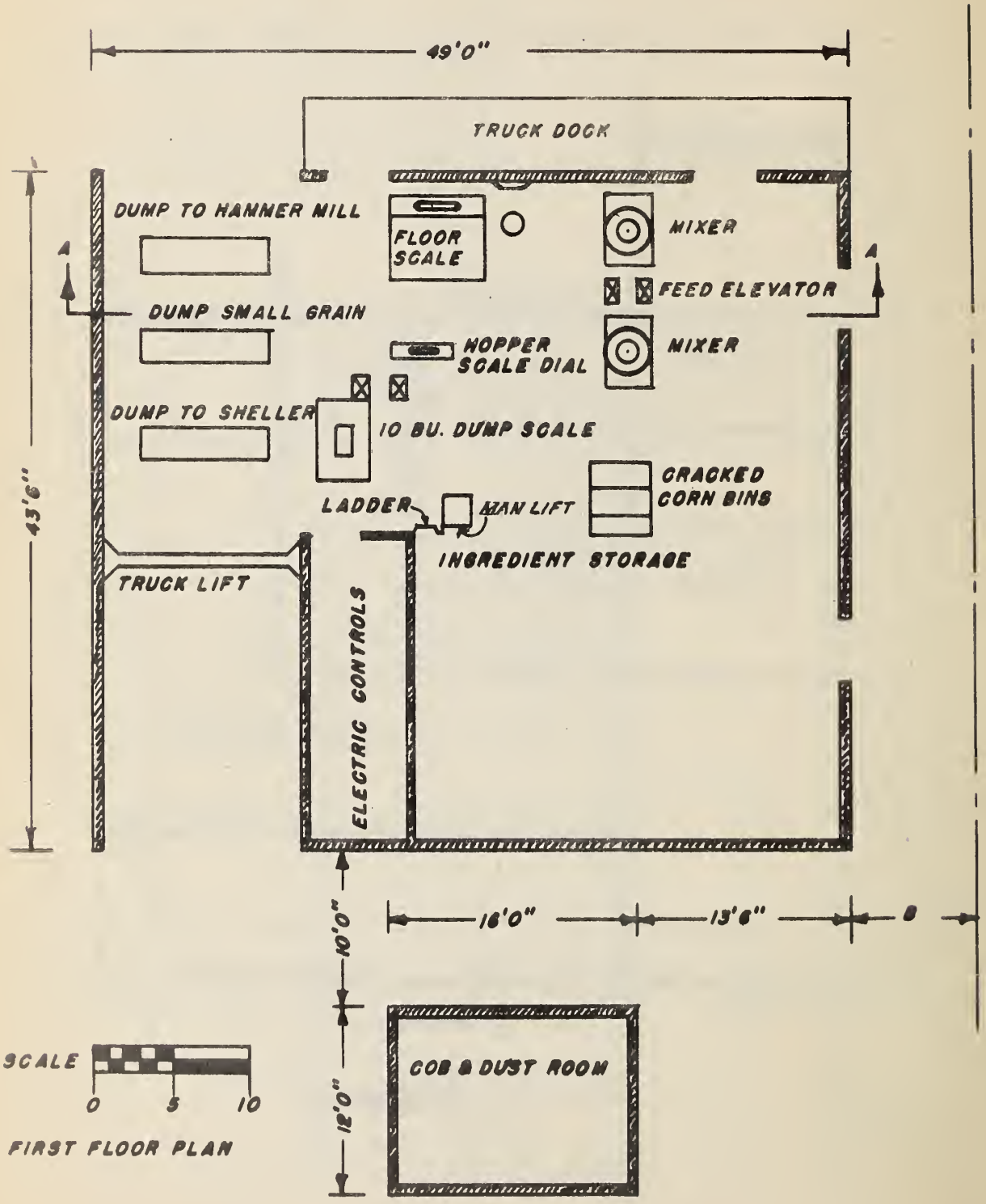
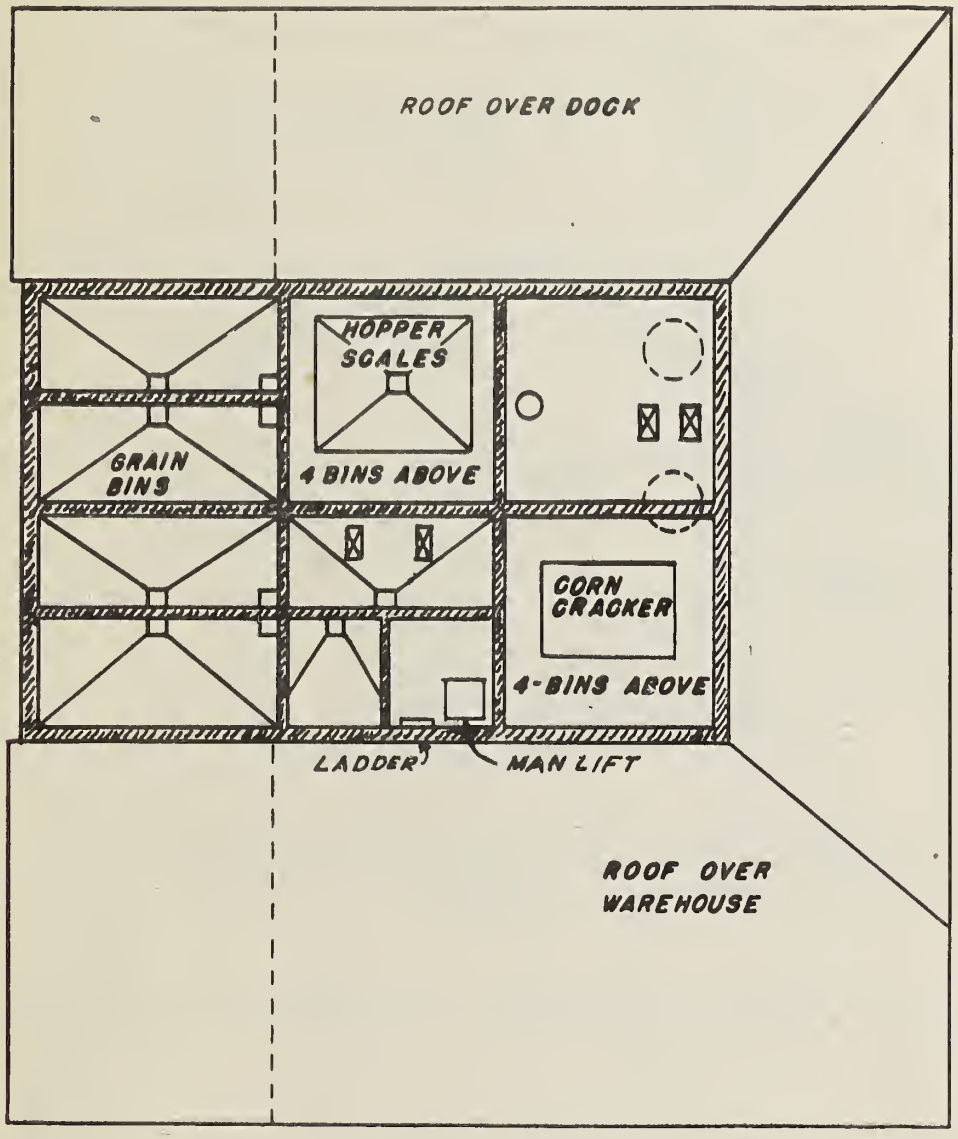


FIGURE 7

MILL No. 1-GRAIN ELEVATOR & FEED MILL COMBINED



SECOND FLOOR

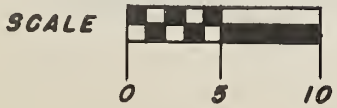


FIGURE 8

FEED MILL No. 2-ONE FLOOR WITH ADJACENT GRAIN STORAGE-SECTION A-A

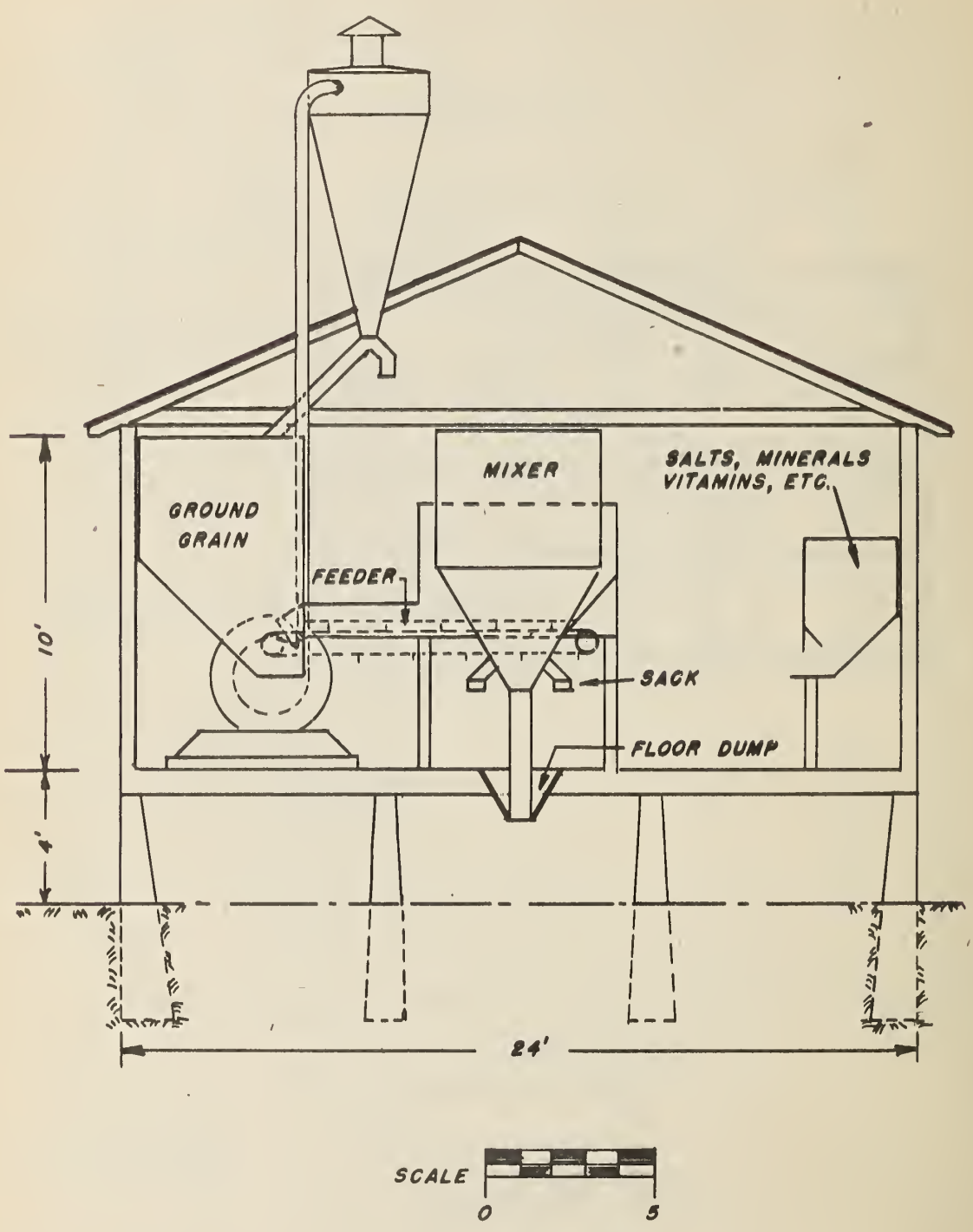
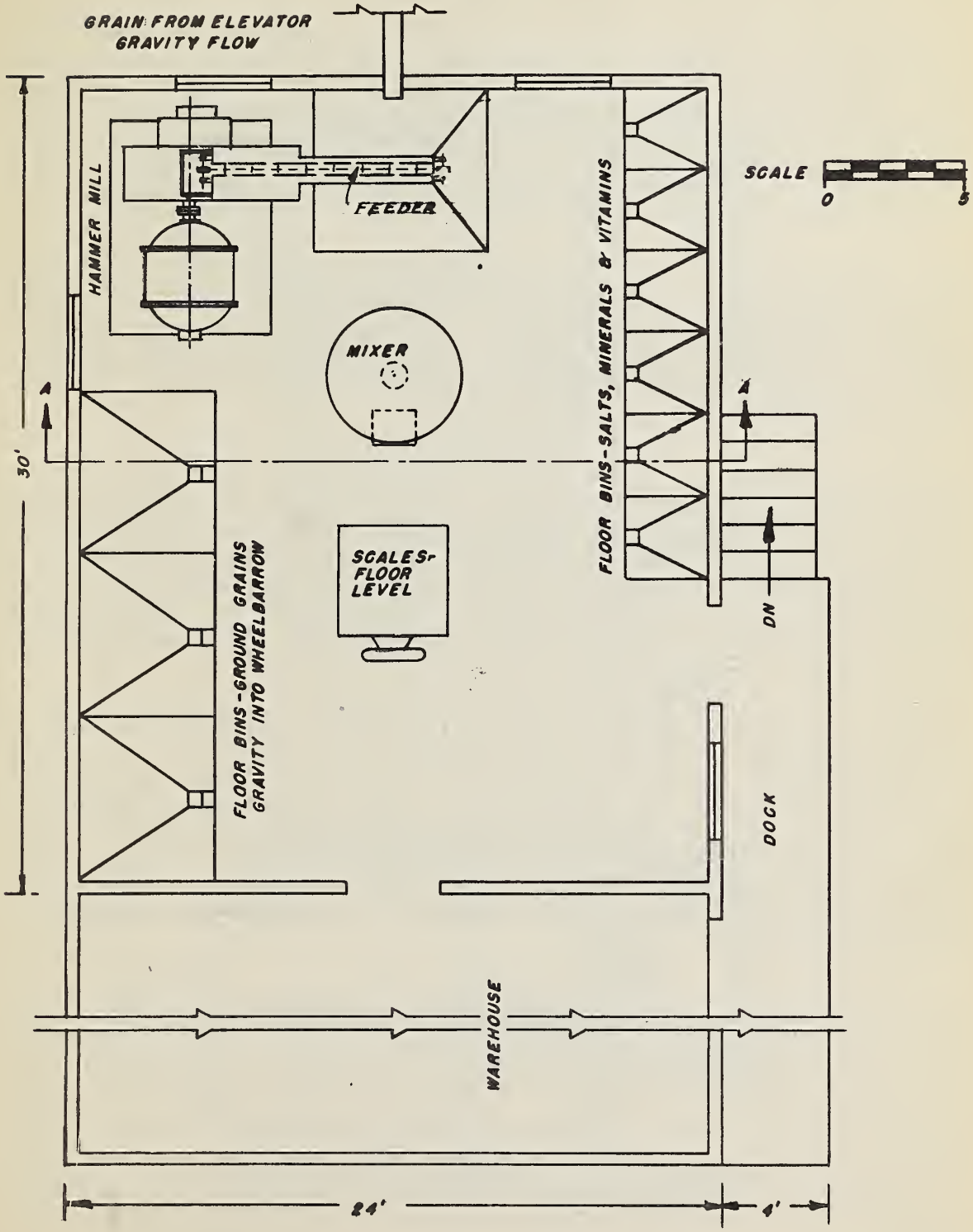


FIGURE 9

FEED MILL No. 2-ONE FLOOR WITH ADJACENT GRAIN STORAGE-FLOOR PLAN



operation by one or two men. The warehouse may be of any size desired depending upon whether farm supplies are handled and the size of the feed business. The quantity and kinds of feeds mixed may be a small part of the total feed business at such mills.

A small mill with an elevator, elevated supply bins, and the hammer mill in a basement, designed for operation by one or two men is shown in figures 10 and 11. The elevated bins may be used for grains or other bulk ingredients. The bins and the elevator are so arranged that material may be transferred from bin to bin. Moreover, ground grain from the collector may be spouted into any one of three of the supply bins. For custom grinding a truck dump could be provided at the end or side of the building and a feeder used for the hammer mill.

The floor scales are shown directly beneath the supply bins for weighing ground grain or bulk ingredients into a wheelbarrow or dump cart and a scale for small lot ingredients. If only one scale is used for weighing all items it may be placed at some convenient point near the mixer as shown in figure 9. Some co-ops use holders for bags of small lot ingredients instead of floor bins.

Small feed mills are often located in warehouses and some are well arranged for efficient operations not only for the mill but for a feed and farm supply business. The great disadvantage of a warehouse is often insufficient ceiling height for machinery. The floor, however, is strong enough in many cases to support the load imposed by stored feed except for the several machines. Figures 12, 13, and 14 show a mill in a warehouse which approaches a regular batch mix manufacturing type of plant.

Farmers' cooperative manufacturing plants sometimes furnish small country point mills with a premix containing much of the protein, vitamins, and minerals needed for a complete feed, which simplifies their mixing problems and reduces the number of work bins from perhaps fifteen to nine (figures 12 to 14). The bins A, B, and C in figure 14 are intended for ground grains and the others for ingredients received in bags. Bin No. 6, which is larger than the other ingredient bins is intended for an item such as soybean of cottonseed meal often used in relatively large quantities in a formula.

The mill illustrated in figures 12 to 14 is designed for operation by three men. With this crew, one man is stationed on the second floor and supplies ingredients to the small work bins and stores ingredients. The other two men weigh ingredients into the hopper scale, bag the feed, and store it on the first floor. One of the two men on the first floor has the responsibility of weighing the ingredients. The job is one which requires accuracy. Mill managers often mentioned the difficulty of finding and keeping a man who realizes the importance of the job of mixing feeds in accordance with a formula and for complying with State laws.

FIGURE 10

FEED MILL No. 3 - FLOOR PLANS OF MILL WITH ELEVATED BINS HAMMER MILL PIT AND ADJACENT GRAIN STORAGE

- ELEVATIONS -

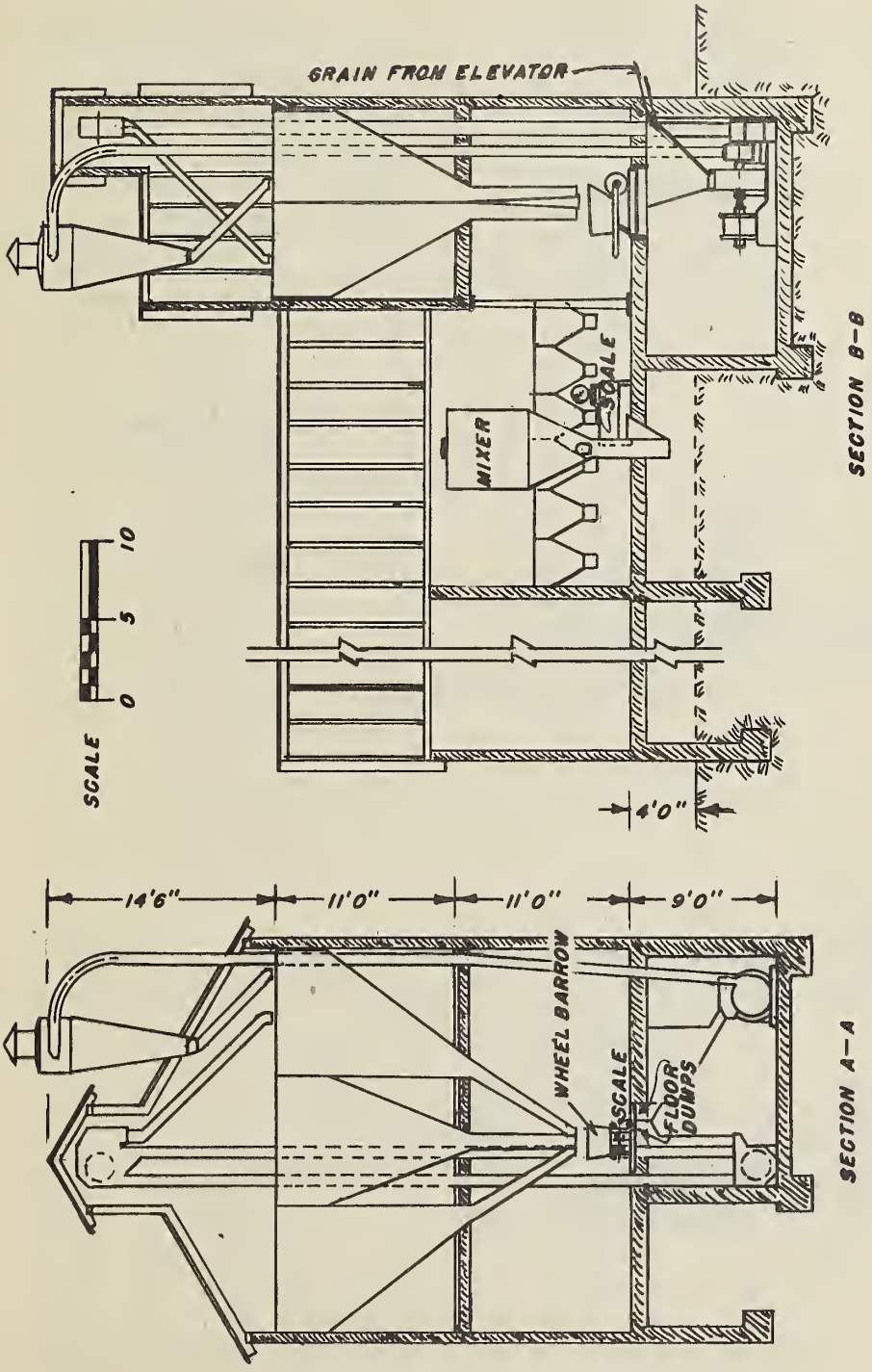
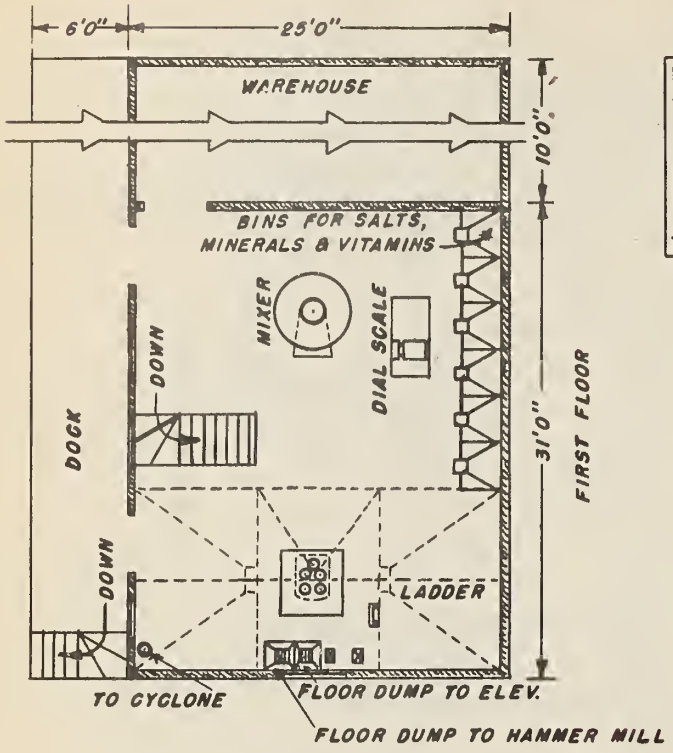
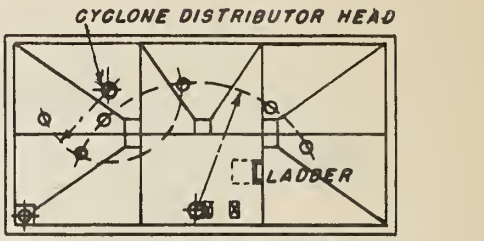


FIGURE 11

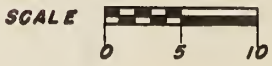
FEED MILL No. 3 - FLOOR PLANS OF MILL WITH ELEVATED BINS, HAMMER MILL PIT, AND ADJACENT GRAIN STORAGE

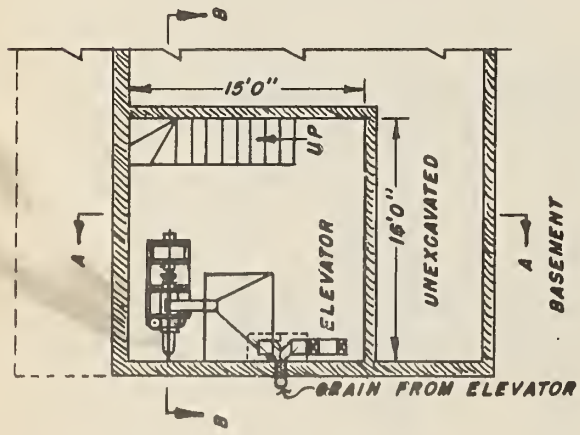
- FLOOR PLANS -

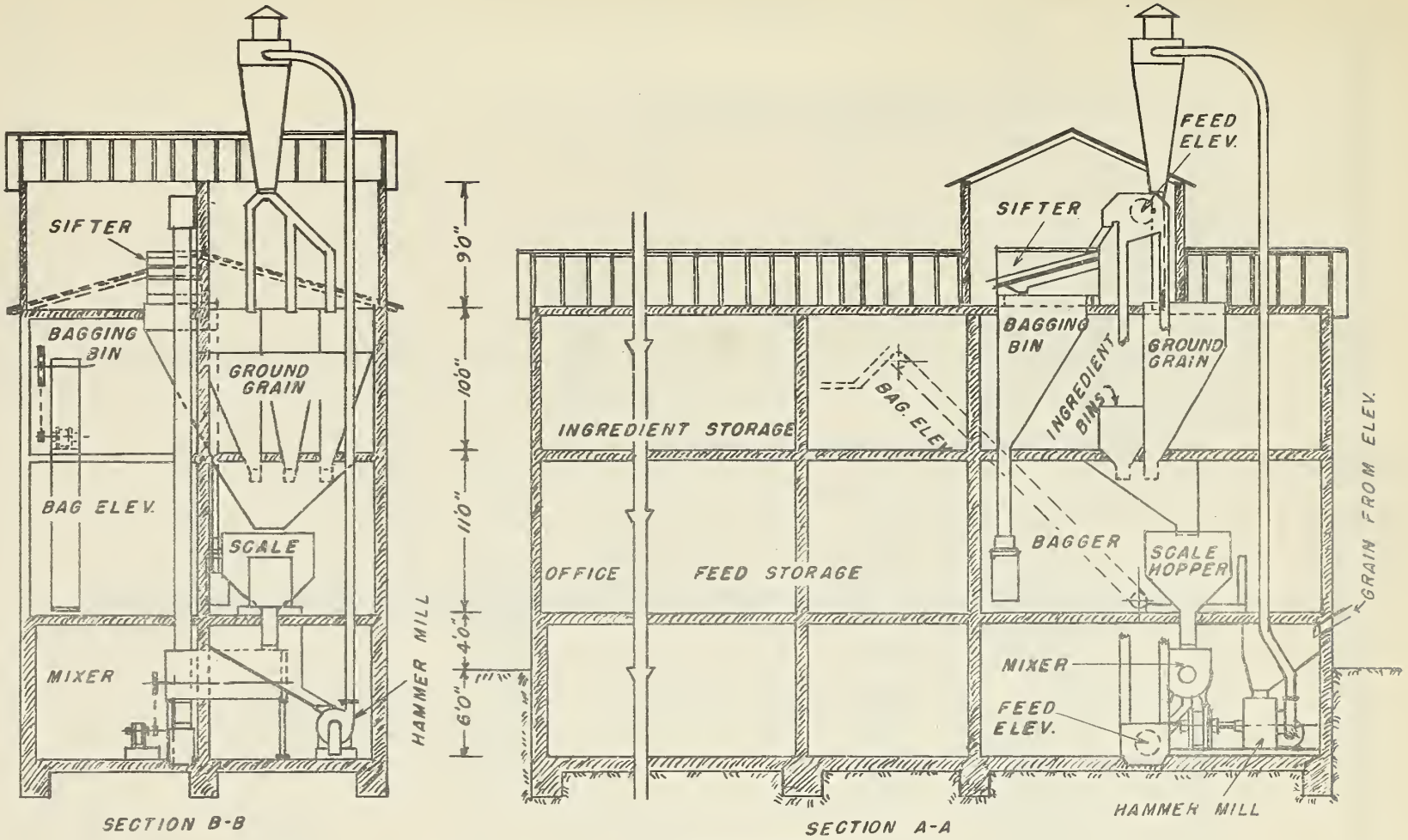




HEAD HOUSE DISTRIBUTION







ELEVATIONS

FEED MILL No. 4. WAREHOUSE TYPE WITH ADJACENT GRAIN STORAGE

0 5 10

FIGURE 12

FIGURE 13

FEED MILL No. 4-WAREHOUSE TYPE WITH ADJACENT GRAIN STORAGE

FIRST FLOOR & BASEMENT

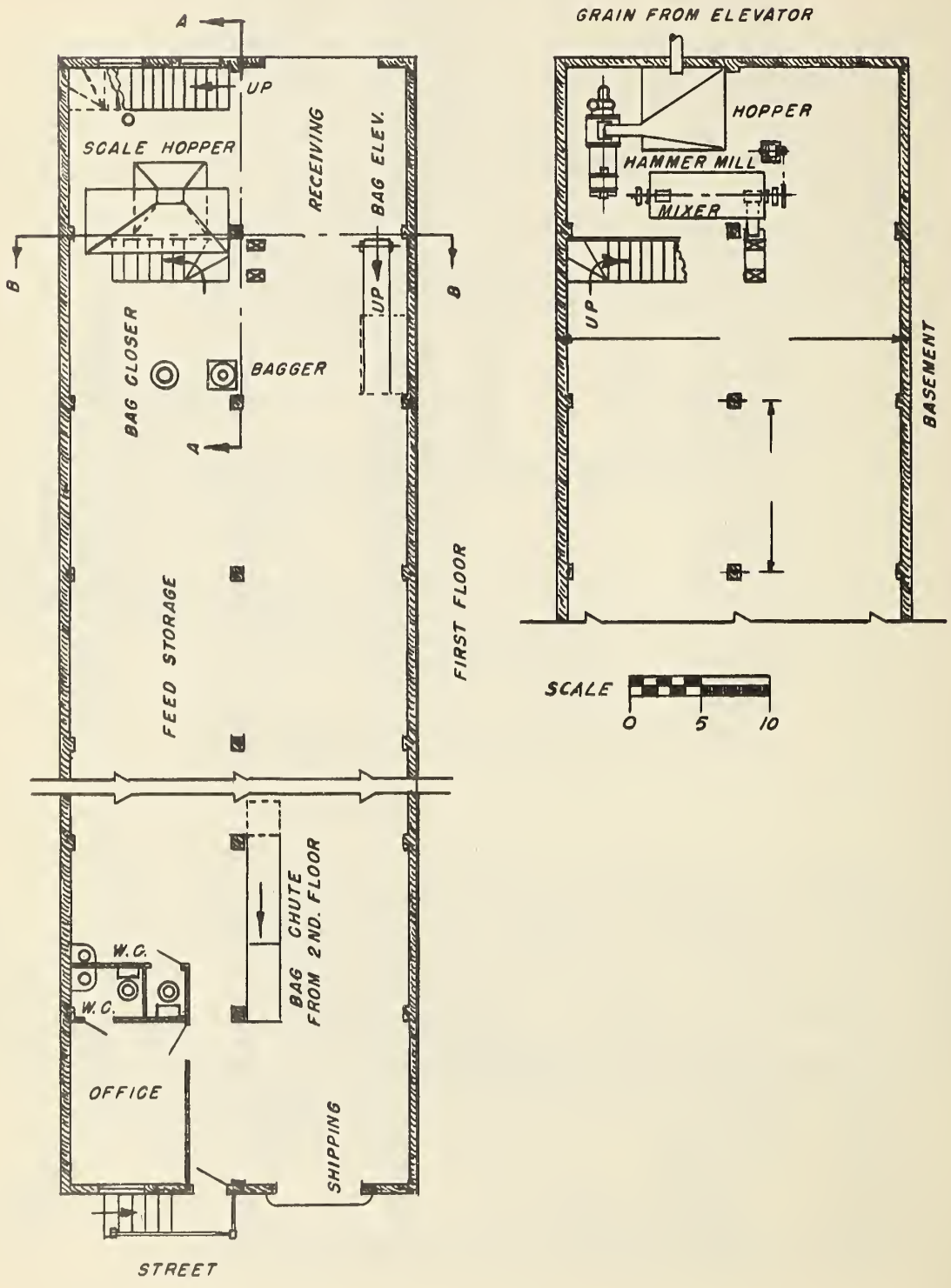
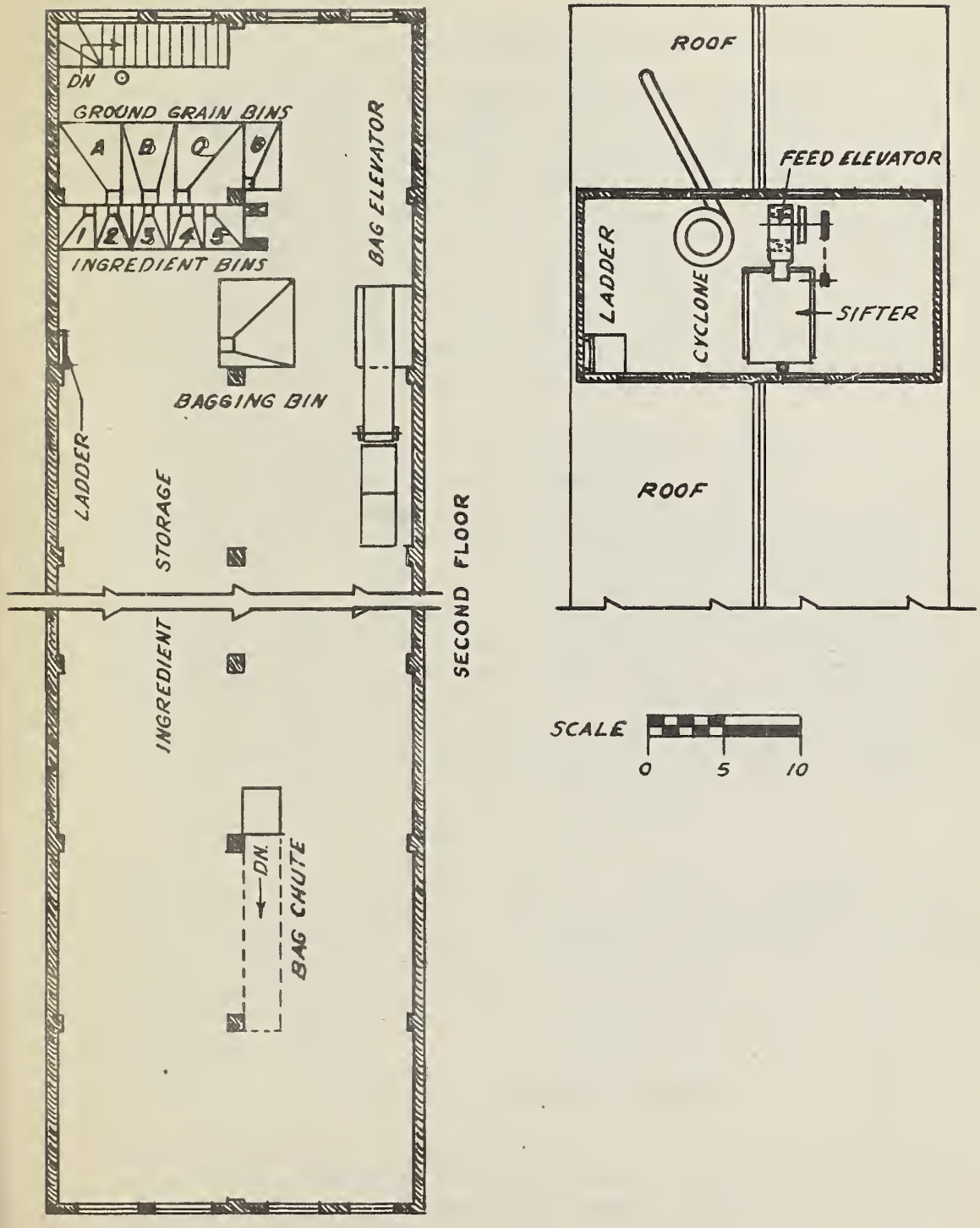


FIGURE 14

FEED MILL No. 4-WAREHOUSE TYPE WITH ADJACENT GRAIN STORAGE
SECOND FLOOR & HEAD-HOUSE



The feed to the hammer mill in such plants as illustrated in figures 12, 13, and 14 as well as the discharge from the mixer are controlled from a convenient point on the first floor. An ammeter is often used to show the load on the hammer mill motor for manually controlling the quantity of grain flowing to the grinder so it will operate close to, but not beyond, a full load.

BATCH MIX MANUFACTURING PLANTS

As illustrated in figures 15, 16, and 17 batch mix manufacturing plants comprise grain storage bins, a mill building, and a warehouse. The mill portion and the warehouse differ little from those in small mills previously illustrated except that they are larger and equipped with machinery for molasses feed, scratch, and pellets, in addition to the regular mash feed. The mill illustrated in figures 15 to 17 has more floor area in the milling section than is customary. While there is no objection to having extra floor space, except for added cost, designers ordinarily provide little space around the equipment. However, for a feed mill of the size illustrated a substantial reduction in floor area in the milling portion would necessitate one or more additional floors.

A majority of the batch mix manufacturing plants visited bag the feed on the second floor. With this arrangement the feed can be loaded into railroad cars or trucks by chutes. The mill illustrated is arranged for truck delivery directly from the bagger by means of a conveyor and chutes.

While the scratch feed line may be followed on figures 15, 16, and 17, a complete batch mix type scratch set-up is shown in figures 18 and 19. It is more elaborate than the usual plant, except in a mill manufacturing large quantities of poultry feed, and has sufficient bins for practically all cracked or whole grains that is likely to be used. Some batch mix manufacturing plants have a line mix arrangement for scratch as mechanical feeders suitable for scratch materials are less expensive and fewer are required than for manufacturing mash feeds.

LINE MIX MANUFACTURING PLANTS

In a line mix plant, as previously stated, ingredients are fed from stock or work bins mechanically and the feed is mixed as the ingredients are conveyed to the automatic scales for bagging, as illustrated in figures 20, 21, and 22. Such plants are designed for production line operations and require a high degree of control. Some line mix plants also have a batch mixer for a premix and for special feeds not well adapted to production line operations.

WAREHOUSE HANDLING

Hand trucks are used exclusively at the small mills for handling sacked feeds and ingredients and are standard items of equipment at most manufacturing plants. In addition, large plants use belt conveyors, pallets, or a combination of both. If the feed is high-piled in the warehouse

FIGURE 15

MILL No. 5- DISTRIBUTION MASH & PELLET LINES BATCH MIX MANUFACTURING

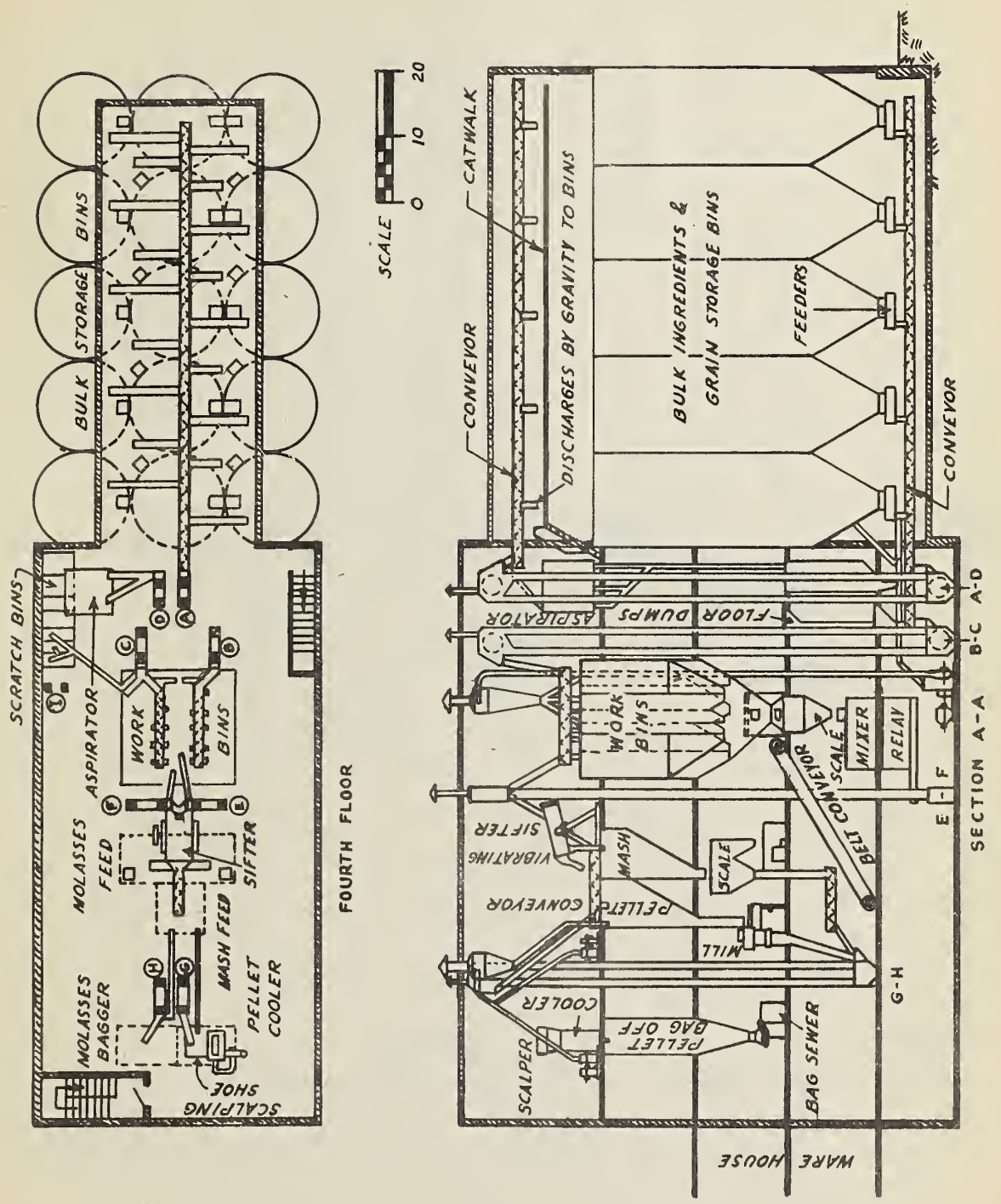


FIGURE 16

MILL No. 5 - BASEMENT & FIRST FLOOR PLANS, BATCH MIX MANUFACTURING

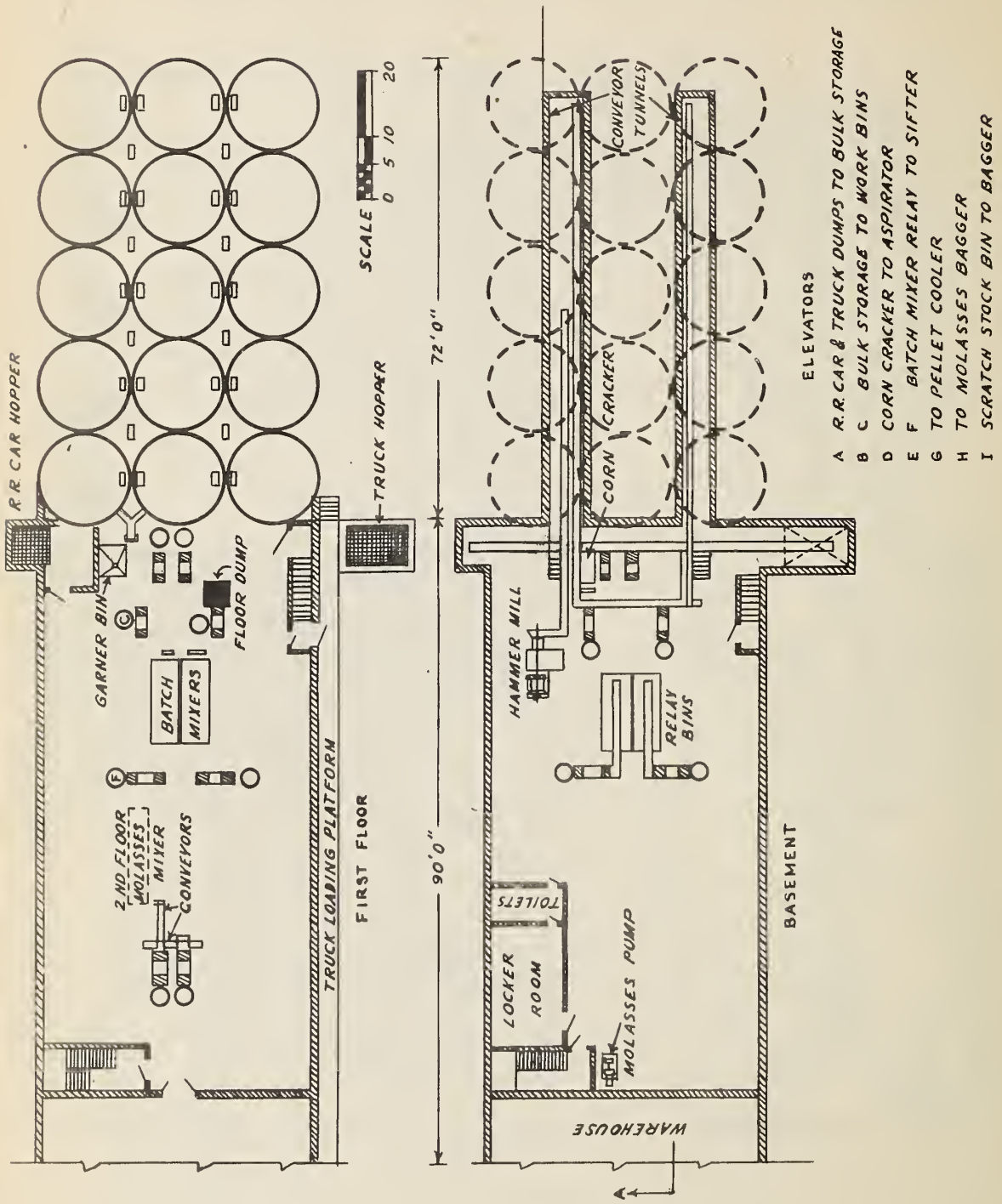


FIGURE 17

MILL No. 5 WORK BIN BOTTOMS & BAGGERS SECOND & THIRD FLOORS, BATCH MIX MANUFACTURING

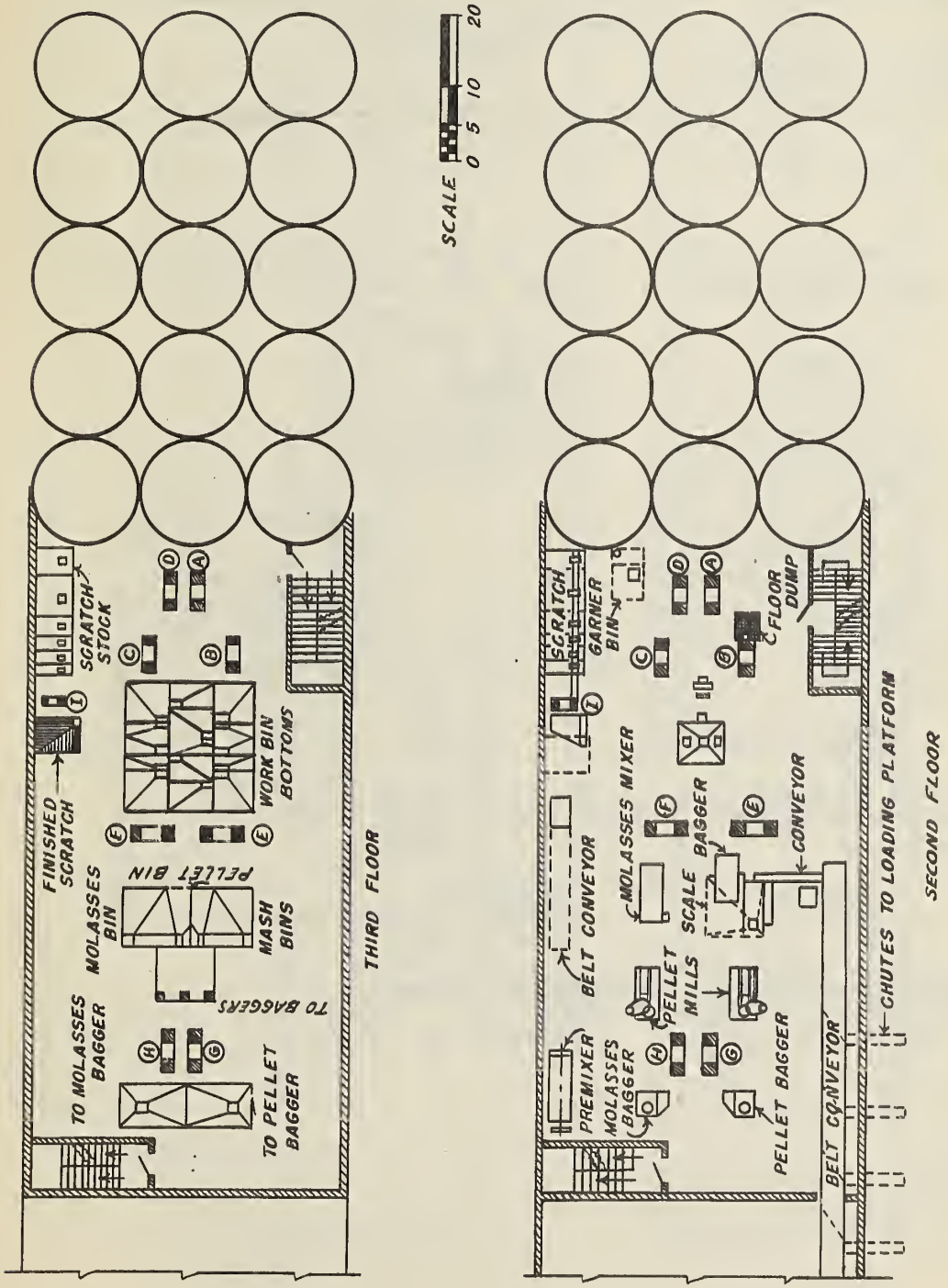


FIGURE 18

MILL No. 6-SECTIONS, SCRATCH FEED MANUFACTURING

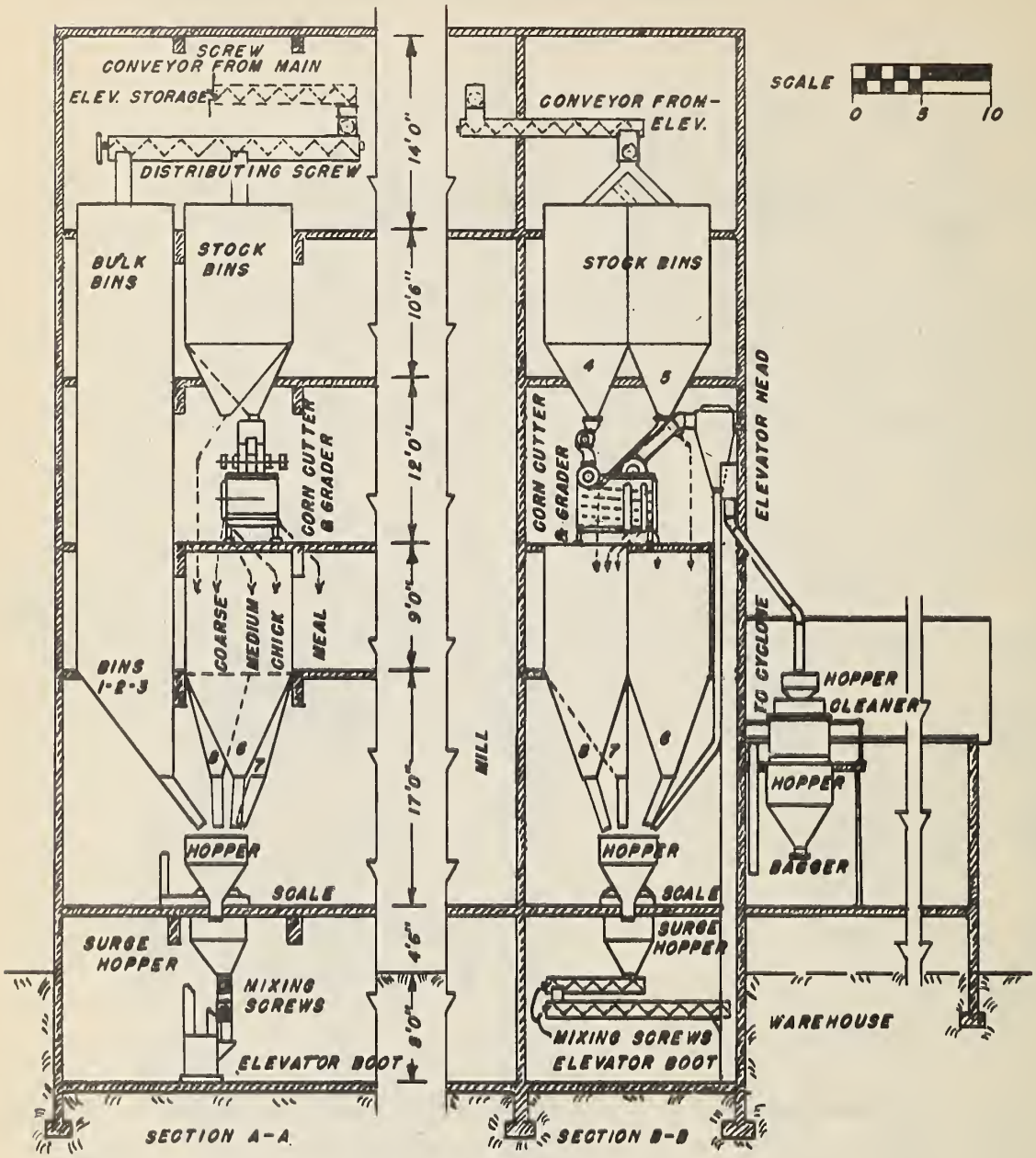
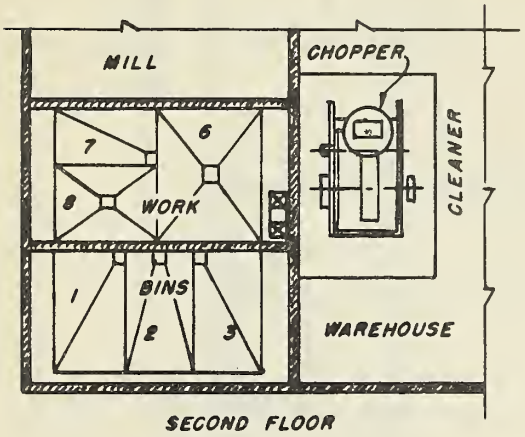
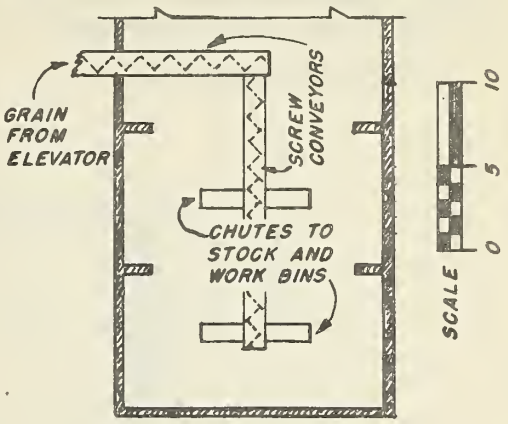


FIGURE 19

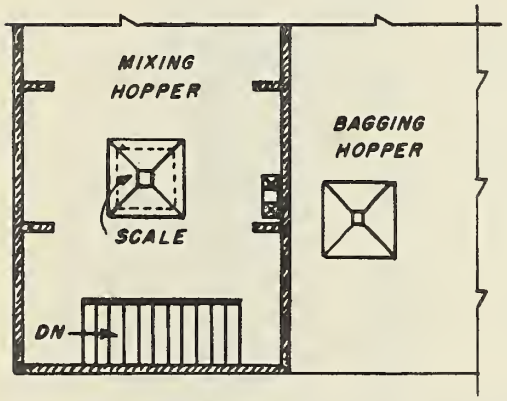
MILL No. 6 - FLOOR PLANS, SCRATCH FEED BATCH MANUFACTURING



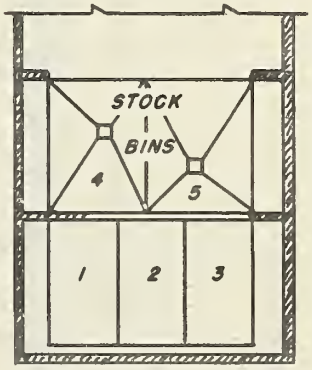
SECOND FLOOR



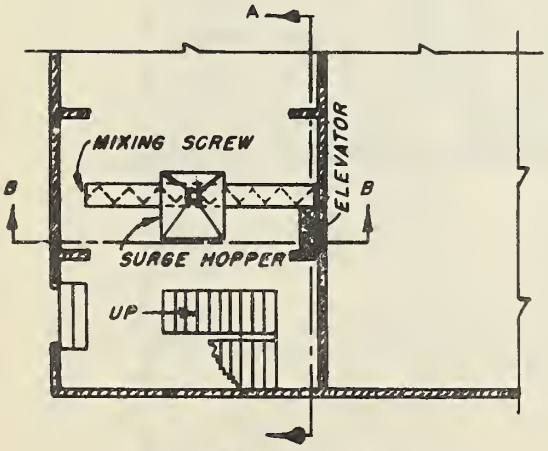
FIFTH FLOOR



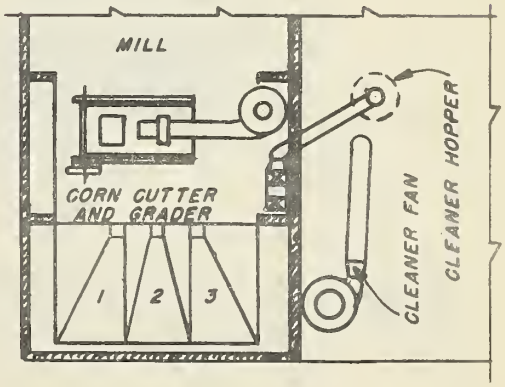
FIRST FLOOR



FOURTH FLOOR



BASEMENT



THIRD FLOOR

FIGURE 20

MILL No. 7-MASH LINE & PELLETS
LINE MIX MANUFACTURING
-DIAGRAMMATIC-

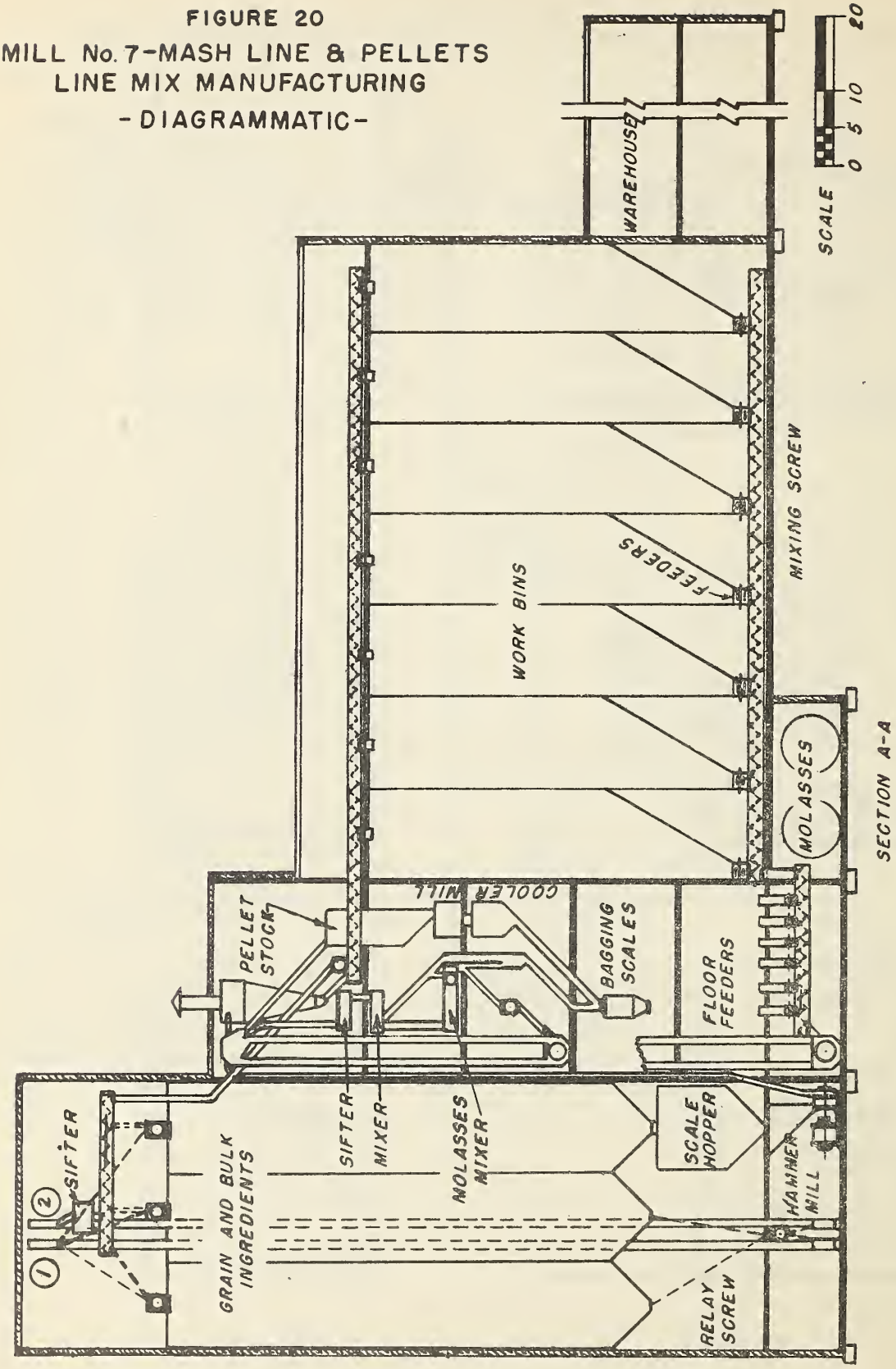


FIGURE 21

MILL No. 7 MIXING SCREWS AND RELAYS-LINE MIX MANUFACTURING

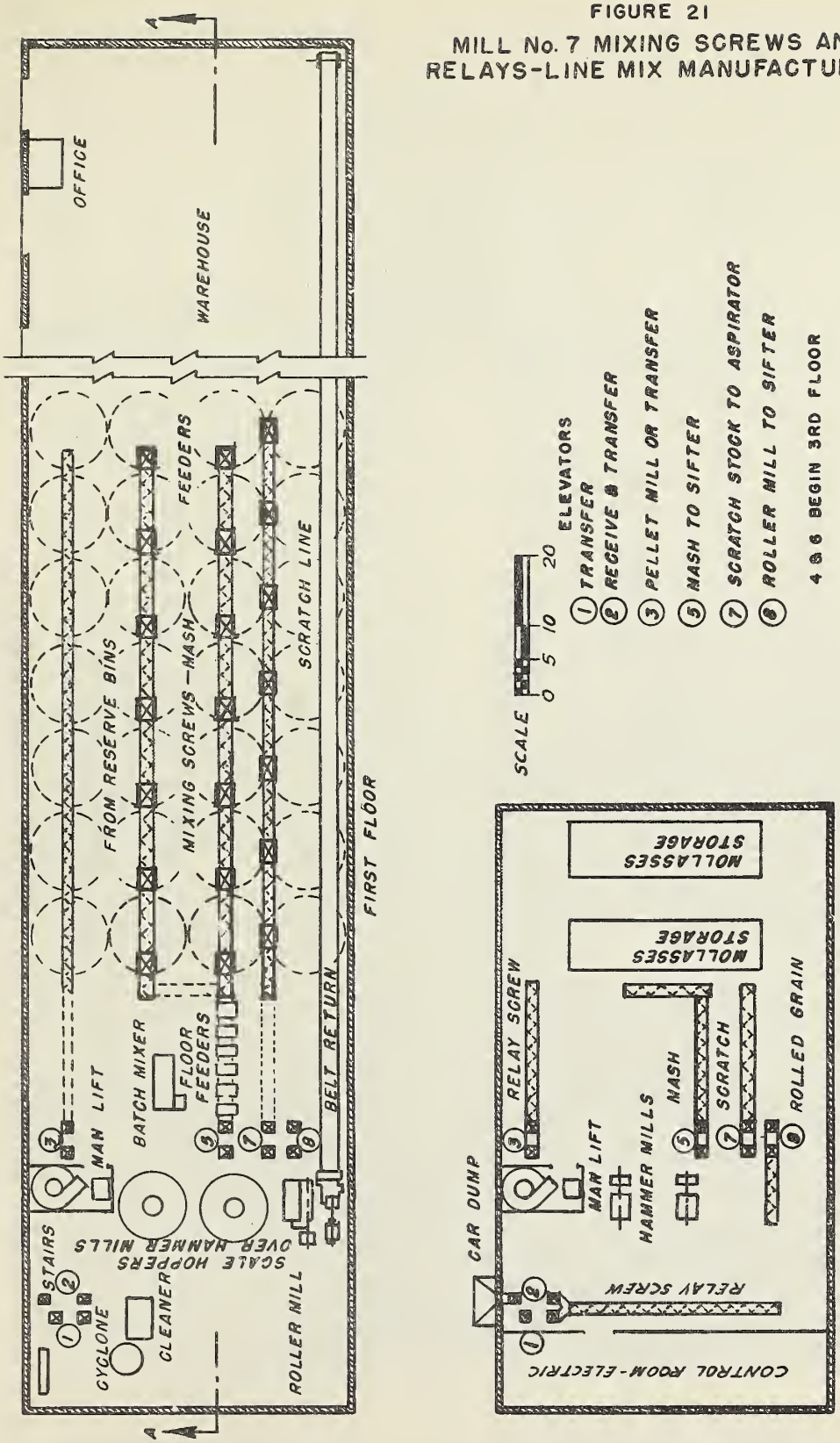
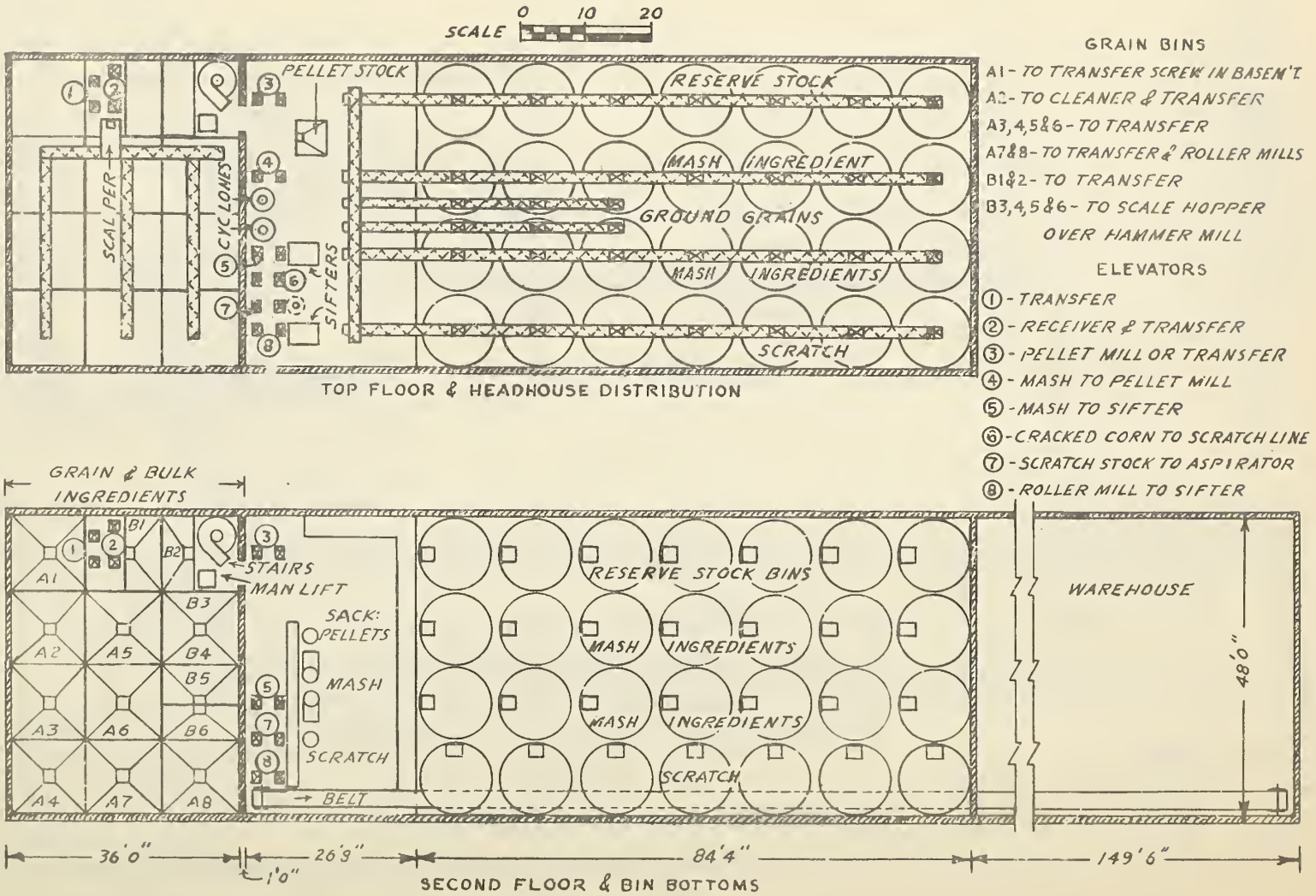


FIGURE 22.

MILL No. 7 - BIN BOTTOMS & DISTRIBUTION - LINE MIX MANUFACTURING



as shown in figure 23, from hand trucks or belt conveyors, bag pilers or elevators are employed. Belt conveyors are used merely to save labor at some points in the mill, or an extensive belt conveying system may be worked out. Figures 24 and 25 illustrate a system of the type often used in moving feed from the bagger to the warehouse.

Chutes may be provided from belts directly to cars or trucks and to points on the warehouse floor for storage. In a one-floor warehouse the conveyer may be suspended from the ceiling.

The use of pallets for feed handling in manufacturing plants has many ramifications. The quantity of feed manufactured, materials handled other than feed, and the general layout of the mill are factors which influence the successful use of pallets. Some mills use pallets for heavy items such as minerals; others use them for all feeds and ingredients. A plant which does some warehousing or can palletize deliveries to distribution points can, of course, use them to advantage. A mill which loads the bulk of its feed into cars or trucks directly from the bagger, or one with a small warehouse where high-piling is necessary seldom attempts to use pallets.

ONE FLOOR OPERATIONS

Gravity flow of materials in a feed manufacturing plant has disadvantages as well as advantages. Heavy machinery must be installed several floors

Figure 23 - High-piling bags in a feed warehouse in the background. The bags in the foreground were stacked in piles five or six bags high by dumping from hand trucks.

FIGURE 24

FEED MILL No. 7-WAREHOUSE CONVEYOR SYSTEM FOR FINISHED FEEDS

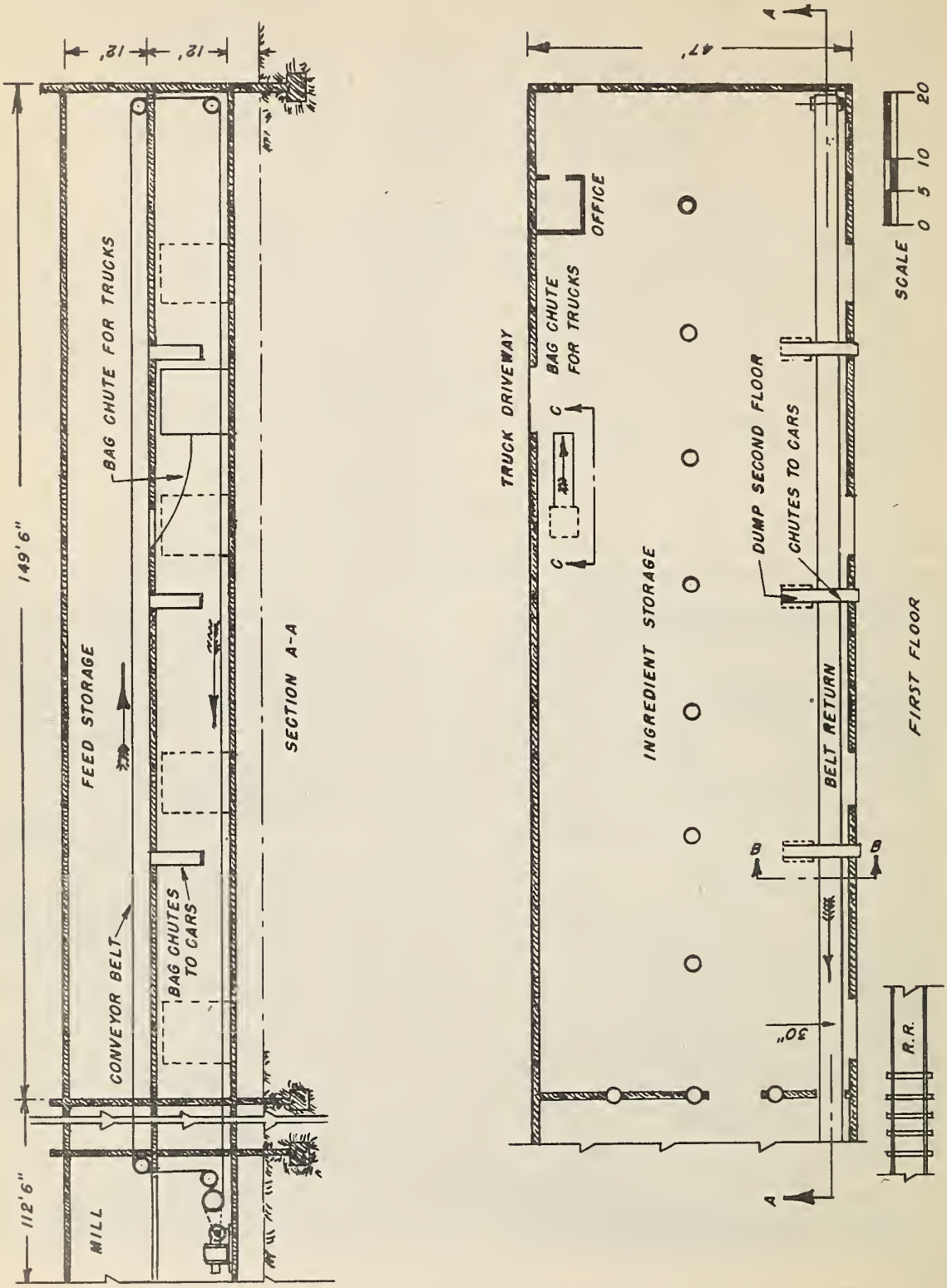
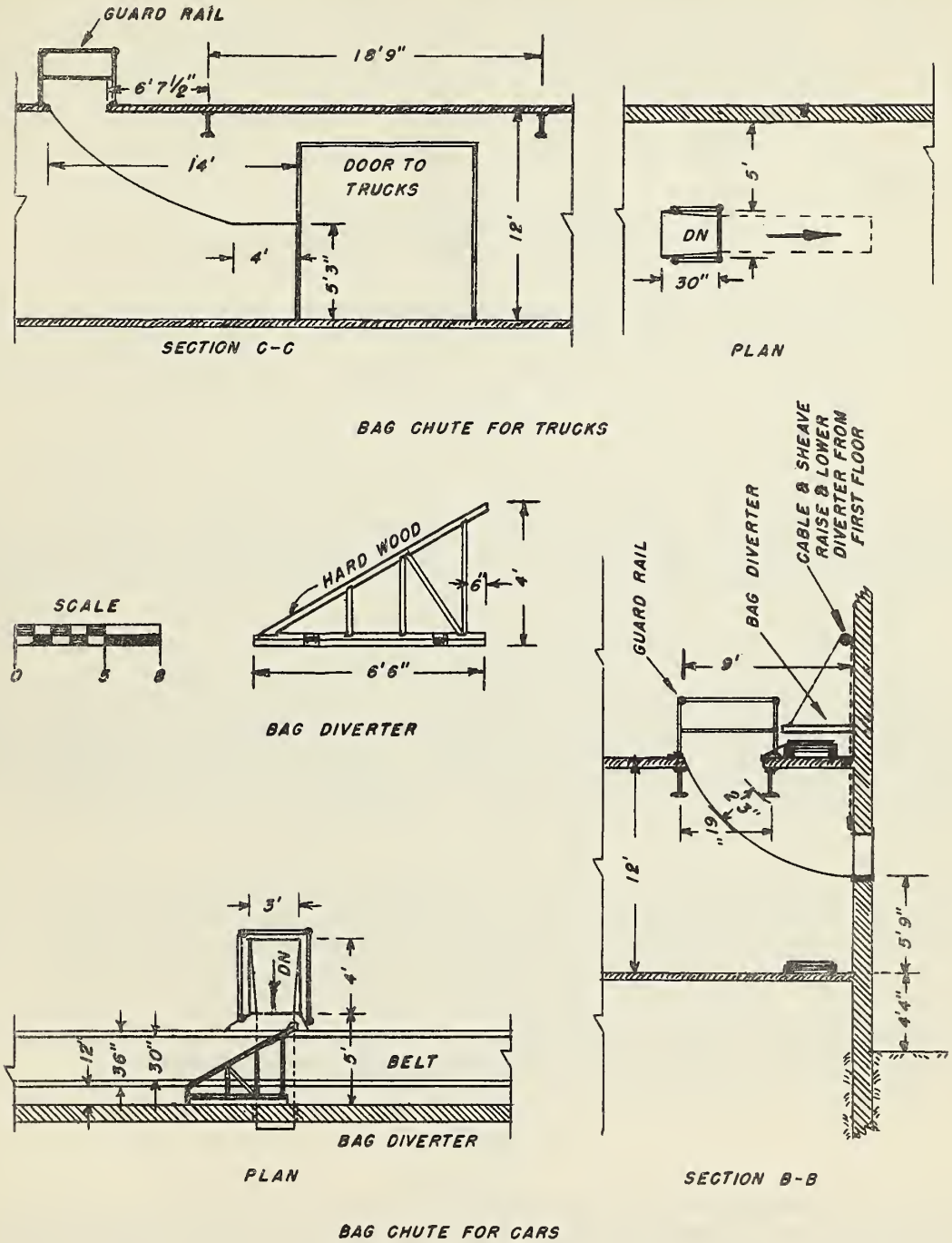


FIGURE 25

FEED MILL No. 7-DIVERTERS & BAG CHUTES FOR WAREHOUSE CONVEYOR SYSTEM



from the ground and on practically all floors. Heavy expensive construction, therefore, is required and, despite the use of automatic machinery, the miller spends much of his time traveling from one floor to another. Some mills station one or more employees at strategic points for control and other plants have extensive electrical control systems. Moreover, a feed mill is a cold place to work in the winter and hot in the summer. For these reasons, some designers are working on plans for locating the bulk of the machinery and operations on one floor.

SIMPLIFIED CONSTRUCTION

The cost of constructing a feed mill with grain storage is not only high but contractors with special equipment must be employed. Experienced builders with the necessary equipment are generally available for such work in the corn and small grain producing areas but are difficult to secure elsewhere except for big jobs. Therefore, small mills need to be designed which can be constructed by local builders.

One idea advanced on grain storage for small batch mix manufacturing plants comprises a line of bins of frame construction, or commercially available steel bins of about 3,300 bushel capacity each, in a battery two or three bins wide wigh gravity flow to a belt conveyor. An existing seed cleaning and treating plant of this general design is reported to use the same belt for both filling and emptying storage bins. This is accomplished by having the belt run out along the top of the bins for filling and return below the bins for bringing the material back for processing. For a feed mill, screws could be used, or a screw for filling storage bins, and a belt for supplying grain and ingredients to the mill from storage.

The mill building for a plant of this type would need perhaps three floors and a basement but an area of not more than 24 x 30 feet. A structural steel framework of conventional design could be used for supporting the work bins and machinery. A warehouse of one floor would be sufficient. The battery of bins, the mill building, and the warehouse might be in line or arranged in the shape of an L or U, depending upon the size and shape of the lot, road, and railroad siding.

BINS

Storage bins for grain and bulk ingredients are of reinforced concrete, steel, tile, and wood. Concrete bins are most common, especially at larger mills. Many of the old mills have cribbed bins. Small bins about a plant, such as work bins, are constructed of metal or wood.

Circular concrete bins are made up to perhaps 20 feet in diameter and rectangular ones with sides up to about 12 feet. Metal bins are circular and may be as much as 20 feet in diameter.

The slope of hopper bottom bins for ground grains and ingredients must be steeper than for grain. A slope of 45° is customary for grain and 60° to 70° for ground materials. Despite a steep slope these materials may not feed properly from a hopper bottom bin requiring a vibrator or air jets to loosen them. Bins for ground grain and mill feeds are often hoppered to one corner thereby reducing the tendency of the material to arch.

Feeds and ingredients tend to separate when allowed to fall a great distance into a bin. Perhaps the simplest device to prevent separation is a square box about 14 x 14 inches extending vertically from about 2 feet from the bottom of the bin to the top into which the feed is fed. This box is open at both ends and has numerous doors hinged from the top on all four sides and extending from the top to the bottom of the chute. As the box fills the pressure of the feed opens the doors and allows it to spill out.

MACHINERY

Manufacturers' catalogues, with specifications and engineering data which were not generally published during the war, are again available and trade publications devote much space to milling machinery. However, comments on machinery made by millers, and general observations may be of interest.

SHELLERS AND CLEANERS

Grain elevators and small feed manufacturing plants usually have their grain cleaner in the head house. In the Corn Belt, grain elevators with corn shellers use this cleaner for corn and spout the cobs to a burner or cob house hereby for disposal. Trouble may be experienced if this system is used with snapped corn. The mass of corn, cobs, and shucks not only clogs the cleaner but a fan or some power driven conveyor is needed for disposing of the husk or shucks as they will not move by gravity in a chute. If snapped corn is to be received, shelling equipment designed for snapped corn should be secured and only the shelled corn handled by the regular feed mill machinery.

Big high-speed bucket elevators at large mills have a capacity greater than grain cleaners and a scalper is used in the head house. In such cases a bin is provided for receiving and holding grain for cleaning and the cleaner is located on a lower floor.

ELEVATORS

Buckets designed for a great variety of materials are manufactured. Some new ones are reported suitable for both mill feeds and grain. Trouble experienced with bucket elevators is often traceable to the wrong kind of buckets, an elevator that is too small. or not designed for the material handled. An elevator designed for grain may do an excellent job of filling the building with dust if used on a light finely ground material. Pneumatic elevators, or air lifts, are reportedly

used in some mills for supplying ingredients to work bins. None were seen in the mills visited except the usual hammer mill installation. Experiments in handling ingredients with small air pipes in positive pressure air pump systems might be worth while.[3]

CONVEYORS

Screw conveyors are used almost entirely for horizontal movement of grain and ingredients at the plants visited despite general complaints as to mixing of the different ingredients. The ordinary screw conveyor is not a precision machine. Furthermore, wear, insufficient supports, improper care, or damage to the housing aggravates this tendency toward inaccurate mixing of ingredients. Materials lodge in the trough when there is a wide space between the screw and the trough, and may or may not be pushed along later by some other material.

A belt is frequently used for grain and ingredients when the job is merely one of moving material from one point to another. Belts would be used to a greater extent except for the space required, complication in dumps for discharge at several points along the way, and in getting material onto the belt. When loading a belt the material should have a velocity approximately the same as the belt to prevent wear on the belt, and bouncing.

GRINDERS

Hammer mills are reported as the most versatile of the grinders used for feed and were found in all plants visited. Large plants often have both hammer and attrition mills in which case the latter is used for hard dry grains and especially for coarse grinding. Several roller mills were observed and reported to be very useful for crushing or cracking grain principally for scratch and cattle feed.

Grinders and other pieces of machinery likely to be damaged by pieces of metal in grain or ingredients or to strike a spark, are equipped with electromagnets. Such devices as well as scalpers and sifters not only protect equipment but remove foreign material which might injure livestock.

Several plants visited had the hammer mill fan located in the head house or on the roof on the exhaust side of the cyclone. With this arrangement a vacuum feeder is required for discharging the cyclone but the system has some advantages. There is no dust leakage from the system in the mill and practically no wear on the fan blades and housing since the ground material does not pass through the fan. A second cyclone located on the discharge side of the fan is recommended for better recovery of finely ground dusty materials.

MIXERS

The majority of small batch mix plants studied used the vertical mixer and the manufacturing plants the horizontal type mixers. The vertical

[3]Bennett, C. A. Cottonseed Handling With Small Air Pipes. U. S. Dept. Agr. Cir. No. 768, 8 pp., illus. 1948.

type is reported to be less expensive and better suited to small scale operations than the others. Most horizontal mixers are faster and the action more positive than in the vertical type. The job of mixing is complicated by the use of trace elements and ingredients with wide differences in specific gravity. Therefore, care must be exercised in obtaining a uniform mix without pulverizing the materials. Such a condition is not only bad from the feeding standpoint, but separation occurs in handling the finished feed.

PELLET MILLS

The use of pellet feeds extends over a period of only 10 or 12 years in this country and the mills only recently came into wide use. Therefore, the pellet machine has not been developed to a point comparable with some other feed milling machinery. Moreover, the successful operation of a pellet mill depends in part upon the feed formulas, the temperature and moisture content of the mash, and the pressure applied. Despite improvements which are being made, there are some complaints on the performance of pellet mills especially as to the life of the dies.

BAGGING EQUIPMENT

Attachments for ordinary platform scales and regular bagging scales are manufactured in such a variety of types and sizes that no mill should be without these time and labor saving devices. The same is true of bag closers; hand sewers with or without a motor; suspension units which may be hung from the ceiling and moved from place to place in the plant; and, the regular production line machines capable of sewing ten bags or more per minute.